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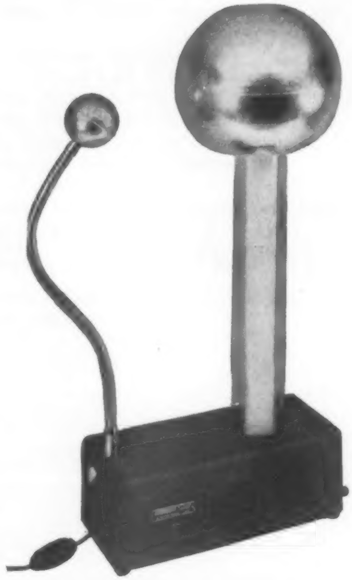

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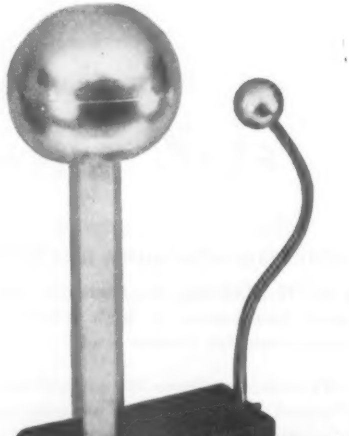

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SCHOOL SCIENCE AND MATHEMATICS

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Attitudes that Obstruct Public Health Measures*

Robert N. Barr, M.D., M.P.H.

Secretary and Executive Officer, Minnesota Department of Health, Minneapolis, Minn.

The Constitution of the World Health Organization, adopted in 1946, defines health and indicates "that the following principles are basic to the happiness, harmonious relations and security of all peoples:

"Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

"The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.

"The health of all peoples is fundamental to the attainment of peace and security and is dependent upon the fullest co-operation of individuals and States.

"The achievement of any State in the promotion and protection of health is of value to all.

"Unequal development in different countries in the promotion of health and control of disease, especially communicable disease, is a common danger.

"Healthy development of the child is of basic importance; the ability to live harmoniously in a changing total environment is essential to such development.

"The extension to all peoples of the benefits of medical, psychological and related knowledge is essential to the fullest attainment of health.

"Informed opinion and active co-operation on the part of the public are of the utmost importance in the improvement of the health of the people.

"Governments have a responsibility for the health of their peoples which can be fulfilled only by the provision of adequate health and social measures."

Webster defines attitude as a state of mental or especially emotional readiness for some form of activity, and indicates that it is

* Presented at the December meeting of the American Association for the Advancement of Science in a panel discussion on Tuesday, December 29, 1959, 9:30 a.m. in Room "K" at the Sherman Hotel, Chicago, Illinois.

synonomous with feeling, set, bearing or air—in short, motivational pattern.

An attitude, then, is an emotional state—personal or growing out of a people's culture—which predisposes to certain types of action. Our public health future depends upon the *fostering* of attitudes that are favorable to our survival and continuous growth, and the *modification* of those which work to our disadvantage. The extent to which we are able to influence attitudes in the direction of advantage is the measure of our success in work toward public health goals. Madison Avenue has devised such clever modes of advertising that our entire standard of living has been changed: we have been subtly conditioned to want many things that our parents did not desire (though they might have had them), and as technology progressed we have been motivated to desire more new products. Our attitudes have been changed in ways we were unaware of, until we now find necessary what we heretofore merely wanted (or perhaps did not know of). This process of adapting our attitudes has been an educational one, but not educational in the blackboard-and-pointer sense. The techniques have been subtler than that, and it is such subtle techniques that health education must discover and employ to work to public health's full advantage. We must in *health* find *necessary* that which we heretofore merely vaguely desired or perhaps left unheeded.

Dr. W. P. Shepard, Vice-President of the Metropolitan Life Insurance Company, states "as medicine progresses beyond the fields of environmental sanitation and acute infectious diseases now so nearly under control and moves toward the increasingly important field of the chronic and degenerative diseases it becomes increasingly more and more essential that we develop skills in the fields of health education. If we are to improve health habits and attitudes we must acquire special skills in communication and persuasion."

Shepard lists five (5) basic principles of good health education that involves changing belief and attitudes. They are:

"1. The other fellow must be convinced that we understand his viewpoint.
"2. He must have confidence in the authority with whom he is talking.
"3. He must understand what we are talking about. This usually means demonstrations in the form of pictures, graphic slides, charts, and other forms of visual aids and then correction of any remaining wrong impressions.
"4. He needs the opportunity to think it over, to make observations of his own and to discuss the new instructions with others.
"5. The opportunity to do what is suggested must be made easy."

This change in health emphasis from the prevention of communicable disease and the control of our environment is today taking place with the same acceleration as is occurring in our technology, our economy, and our way of life.

In fact, in some respects our technological acceleration is ***competing*** with our public health goals; our people want many ***things*** more than they want health. The payment on the car takes precedence over medical care, and we know that motivation is behind the differential between what people spend for liquor, tobacco, cosmetics, and other consumer items and what they spend for health. Attitudes toward these are different.

Association with new technological and social developments are new health problems, such as the many radiation health hazards resulting from the development and use of atomic energy and other radiation sources.

Likewise, other health problems which appeared to be under fairly adequate control grow to major proportions. Good examples are those associated with our exploding population and its migration to the urban areas, the latter due to our industrial growth. Such have placed undreamed-of demands upon our educational system and our community health services,—including our medical and hospital services and environmental sanitation facilities.

Our young people with their growing families are rushing into our suburban areas, thus creating new communities that tomorrow will become cities, with all the problems and needs of modern metropolitan areas. Some of these needs include city government, schools, hospitals, health services, police and fire protection, water supplies, sewer system, sewage and waste disposal. All are costly, but without them a modern community could not long exist.

Are health attitudes of these exurbanites keeping pace with these changes? In many cases the answer is yes. When a community suddenly discovers that because of the proximity of its private wells and sewage disposal systems its members are, in effect, drinking their own dilute sewage, the force of community effort to meet this problem can be very gratifying. The attitude of the people is good: The adequacy of their action is directly proportional to the skill with which they have been educated in health matters.

Today, as yesterday, our greatest health need is good health education and with it public understanding. An understanding on the part of our citizens, young and old, of the importance of higher education, including health education, of the welfare of our society and their relation to its economy and its progress.

All are so interwoven that none of us can draw a dividing line between that which is a health problem, an education, an economic, a welfare, or a social problem. Neither can we draw a sharp line of division between the part that government (national, state or local) is responsible for and the part that the individual, the voluntary organization, the professional group, or industry or labor should play.

Thus, our only recourse is to outline the objectives that all of us are shooting at and then collectively at the national, state and local level steer as direct a course as is possible to attain these objectives. This means that we need leadership, knowledge and understanding, and a willingness to work together for the common good. Government and the voluntary agencies, the professions in the health field, labor and industry, as well as John Q. Public, must understand the health needs of the community, the state, the nation and the world, and be willing to submerge their prejudices toward achieving those needs.

We must think, not just rearrange our prejudices. We must understand that the achievements in health today as in the future are not solely the achievements of any one group: they are the attainments of a complex society whose economy, standard of living, education, industrial and agriculture production have all moved ahead to high levels. In this, the scientist, the physician, the health worker, the educator, the community leader, the individual and the group all have had a part.

We have been requested to indicate what attitudes obstruct public health measures. If you will accept immaturity of a people and a society as an attitude, then, I am sure, that we must place immaturity of people, individually and collectively, in first place as the greatest single attitude (indeed, the all-encompassing one) that obstructs progress in public health.

We demonstrate this through our failures to take leadership when leadership is sorely needed, by our social and religious prejudices, by our fears that government is becoming too powerful and may destroy us when in reality *we are* the government and it is our responsibility and duty as citizens to see that government remains as a useful tool of our society.

We demonstrate it when we propose health, social and economic, and educational changes for which society is not prepared nor geared to handle if adopted; when we say do as I tell you not as I do; or it will never happen to me. We demonstrate it when we say the government should do this for me, and at the same time complain that our taxes are too high, or there ought to be a law—when we dump our feeble-minded child or our aged parents onto society to care for and refuse to assume any personal responsibility even if we are able to do so. When we vote dry and drink our share of the nation's annual liquor supply. When we expect the school system and the church to provide all the education and training for our children and complain about juvenile delinquency, the quality of education, and taxes. When we think that the man who agrees with us is a scholar and he who disagrees is a fool or a knave. When we define education on the basis of the number of degrees an individual has and attempt to place

his value to society and industry on the same basis. When we advocate a shorter work week and are at a loss to make use of the leisure time we now have. When we sing the praises of the good old days and decry the present, for example,—a dollar was worth a dollar then, now it's worth fifty cents (50¢), a hospital bed cost $8 to $10 per day, now it costs $25 to $30 per day or more, our boys were strong and tough in the good old days, now they are softies—are going to the dogs—can't do a day's work, and are no good as soldiers.

All of these attitudes are indications of our immaturity, our lack of true education and understanding and our inability or unwillingness to assume our individual and collective responsibility as members of our modern society. I wonder what our forefathers would think of us if they could see us today. True, they would marvel at our technological accomplishments, but might they not also scorn us for our attitudes toward the responsibilities that came to us with those accomplishments?

An excellent example is the study of the attitudes of leaders relative to the costs of industrial health medicine recently made by Dr. Frank A. Calderone, industrial health consultant, to quote: "tremendous differences mark the attitudes toward proper scope of future programs. Industry wants expansion held within narrow limits. Unions seek almost unlimited expansion. Medical opinion is mixed but tends to view expanded medical programs with foreboding and is particularly concerned with maintaining the status of the individual physician in any future pattern. . . . Future leadership is a storm center of violent and acrimonius opinion."

It is interesting that the author also reported that both management and labor emphasized the importance of preventive need in industrial health while medical opinion on the contrary was lukewarm or cold to its value.

This is only one of the many problems in today's public health that remain unsolved because of poor communication and understanding, lack of strong dynamic leadership from within the field on the part of those who have the expert knowledge.

Harry Bullis, Chairman of the Board of General Mills, Inc., is quoted as follows: "It is imperative for our survival that we develop an army of intellectually grown up men and women."

It cannot be over-emphasized that motivation for good health as relates to chronic diseases is primarily an individual problem and thus requires different health education techniques than have been used in the prevention of communicable disease or the control of environmental sanitation problems. A community water and sewer system can be constructed by a municipality following a majority decision made by the registered voters. The costs of such being spread

over several years as a mill levy against all taxable property. In addition, such a health measure has more than a health appeal to the individuals in the community. It provides each resident and building with the luxury and convenience associated with safe running water and sewage disposal. These are facilities that almost all of us have learned to appreciate and desire as a result of many years of experience. The municipality can also require by law that all dwellings make use of these utilities. Such authority is based on public acceptance of these utilities as good sanitation and health facilities. In a like manner, public health laws now require individuals infected with a communicable disease to take precautions against the spread of such disease to those in the community.

In the case of chronic disease control there is no danger of its spread to other members of the family and society is unaffected except through the disability and death of the individual member. This results in a productive loss to the total group and may also result in the individual's dependents becoming a social and economic liability to society. Consequently, here health protection becomes an individual problem and motivation requires considerable different approach.

Perhaps in selling good health we should look to industry for guidance and learn to make people desire good health with the same enthusiasm as they seek new luxuries.

At the same time we must not forget that all of these programs take time; that those promoting such have had to learn to run by first walking.

If we look back we will note that there was almost 100 years delay between the time Edward Jenner discovered smallpox vaccination in 1796 and its general public acceptance; that over 20 years elapsed between the time that Ignaz Semmelweiss concluded that puerperal fever was an infectious disease and its acceptance by the medical profession.

We will also note that each new discovery has been accepted with greater rapidity; the last one being the acceptance and the use of Salk vaccine to prevent paralytic poliomyelitis.

A review of World Health programs show that tremendous progress is being made in the improvement of health of all peoples of the world and some of these programs, like malaria control, now have as their objective the eradication of the disease. The reports of this organization are full of comments relative to health beliefs and attitudes based on tradition, religious beliefs and customs. All of which required a complete understanding before health programs become productive.

A Study of the Influence of an Inspirational Science or Mathematics Teacher Upon Student Achievement as Measured by the National Merit Scholarship Qualifying Test*

Goulding E. Sanderson** and Kenneth E. Anderson
Dean, School of Education, University of Kansas

Introduction

Since that fateful evening when Russia released Sputnik I, education has increasingly come under the scrutinizing eye of both professional and lay groups throughout the country. The Educational Policies Commission of the National Education Association[1] notes that education is a life long process which begins before a child enters elementary school and continues throughout the years of formal education, and then as long as life continues. During the years of formal education, the school curriculum may be considered as all the experiences the child has in connection with the school, including not only organized learning experiences but also such activities as assemblies, clubs, athletic events, student council, and adult activities in which the schools participate. The educational growth of the individual, particularly in the early years of childhood, is the result of the balance between influences in the home and school. As a child grows older the school influence becomes stronger and as he reacts to the school environment, certain patterns of growth and behavior are established which become part of his developing personality. Infinite variations in the biological characteristics of each individual acted upon by variations in the school environment as it changes from class to class and year to year, produce individuals with truly unique personalities. As the individual is influenced by the school environment, many different types of learnings are organized into the nervous system and become habits, understandings, attitudes and skills. During this period the individual is especially receptive to formation of interest patterns and, depending upon his innate ability in a particular area, can be greatly influenced by the guiding hand of an inspirational teacher.

The Problem

Recognizing the importance therefore of an inspirational teacher

* This article is based on the findings of the unpublished Master of Science in Education thesis completed by Goulding E. Sanderson at the University of Kansas in September 1959, under the direction of Dean Kenneth E. Anderson.

** Assistant in the Bureau of Educational Research and Service, 1958–69.

[1] Educational Policies Commission. ***Education for All American Children.*** National Education Association, Washington, D. C., 1948.

upon the developing personality and future academic achievement, the writers examined test score results on the *National Merit Scholarship Qualifying Test* of individuals who indicated on a follow-up questionnaire, sent out by the University of Kansas Bureau of Educational Research and Service, as having studied under an inspirational teacher in a particular subject matter field. The writers then accepted as the general problem of this study the determination of what differences, if any, existed in achievement between students who indicated having had inspirational teachers in a particular academic field and students who indicated not having had inspirational teachers in the same academic field.

The academic areas of science and mathematics were then selected for study and evaluation. The test scores of students who indicated having had inspirational science teachers were tabulated, followed by those of students who indicated having had inspirational mathematics teachers. Scores were obtained for the following test areas: English Usage, Social Studies Reading, Word Usage, Mathematics Usage, and Natural Sciences Reading. In order to have a control group for comparative purposes, test scores were obtained for individuals who did not indicate having had inspirational science or mathematics teachers. It was then possible to determine the extent of the differences in achievement between the groups under comparison.

If statistically significant differences were obtained between the means of the test scores for the two groups of students in favor of those students who had inspirational teachers, then it may be hypothesized, other things being equal, that the students of inspirational teachers will achieve more in academic areas than the students of non-inspirational teachers.

Procedures Followed in This Study

On April 29, 1958, 7,110 students of junior classification from 322 high schools in Kansas took the *National Merit Scholarship Qualifying Test.*

In February 1959, the above students who were now classified as seniors completed a questionnaire prepared by the University of Kansas Bureau of Educational Research and Service.[2] The writers then inspected the returned questionnaires to determine student answers to the following question: "In reviewing your high school years, do you feel you have had an inspirational teacher who was a recognized teacher of excellence in his or her field?"

The writers then examined the questionnaires of those students

[2] Kenneth E. Anderson. University of Kansas General Research Project 4542-5570: A Study of the 1958 Kansas Participants in the National Merit Scholarship Program

answering in the affirmative to the above question in order to determine answers to the following question: "If your answer to the previous question was yes, in which of the following subject-matter areas was this teacher?

1–Mathematics
2–Social sciences
3–English and speech
4–Science
5–Foreign language
6–Vocational (home economics, agriculture, business, industrial arts, etc.)
7–Music
8–Art
9–Physical Education."

Of the students answering in the affirmative to the first question, the writers then chose one hundred who indicated having had an inspirational teacher in mathematics and one hundred students who indicated having had an inspirational teacher in science. An additional one hundred students who did not answer yes to the first question or did not have an inspirational teacher in high school were chosen as a control group. The 300 students so chosen were selected by the use of random numbers. Hereafter the group indicating having had an inspirational science teacher was designated as the Science Group, the group indicating having had an inspirational mathematics teacher was designated as the Mathematics Group, and the group indicating not having had an inspirational teacher was designated as the Control Group.

Following the selection and identification of the three groups indicated above, the writers established master tabulation sheets for each group. Standard test scores were recorded for the three hundred students in the study for the following tests of the *National Merit Scholarship Qualifying Test:* (1) English, (2) Mathematics Usage, (3) Social Studies Reading, (4) Natural Sciences Reading, and (5) Word Usage. In addition to the above test results the following composite scores of the *National Merit Scholarship Qualifying Test* were tabulated: (6) Science Composite, (7) Humanities Composite, and (8) Total Composite.

A series of t tests were then run comparing the differences between means, first of the science group versus the control group and then the mathematics group versus the control group for each of the five sub-tests and the three composite scores, in order to reject or fail to reject (accept) the null hypothesis under test. Before the t tests could be run, however, it was necessary that the assumptions of normality and homogeneity of variances be established. The assumption of nor-

mality was not tested since it was felt that the test scores from the large number of schools from which the samples were drawn would tend to produce a nearly normal distribution. Also, it has been proved that no serious error in the t tests will be introduced by a slight departure from normality.[3] The second assumption of homogeneity of variances was tested for by using the F ratio test. All but one of the resulting F values were smaller than the criterion value at the five per cent level of significance. One F ratio was significant at the 5 per cent level but not at the 1 per cent level. Therefore the assumption of homogeneity of variances was met for each comparison. The eight tests comparing the science group with the control group and the mathematics group with the control group were then completed.

Results of the Analysis

Table 1 gives the results of the t tests run for the groups indicated. On the basis of the computed values given in this table it is possible to make the following statements:

1. For the science group versus control group there were differences in the means as follows:
    a. English Usage test means showed that the science group did not achieve significantly more than the control group in this area.
    b. Mathematics Usage test means showed that the science group achieved significantly more than the control group (at the 1 per cent level) in this area.
    c. Social Studies Reading test means showed that the science group did not achieve significantly more than the control group in this area.
    d. Natural Sciences Reading test means showed that the science group achieved significantly more than the control group (at the 5 per cent level) in this area.
    e. Word Usage test means showed that the science group achieved significantly more than the control group (at the 1 per cent level).
    f. Science Composite score means showed that the science group achieved significantly more than the control group (at the 5 per cent level).
    g. Humanities Composite score means showed that the science group achieved significantly more than the control group (at the 1 per cent level).
    h. Total Composite score means showed that the science group

[3] W. G. Cochran. "Some Consequences When the Assumptions for the Analysis of Variance Are Not Satisfied." *Biometrics*, 360 (March, 1947) 22–28.

achieved significantly more than the control group (at the 1 per cent level).

TABLE 1

VALUES OF t DETERMINED BY COMPARING MEANS OF THE SCIENCE AND CONTROL GROUPS AND OF THE MATHEMATICS AND CONTROL GROUPS FOR EACH OF THE FIVE SUB-TEST AND THREE COMPOSITE SCORES ON THE *National Merit Scholarship Qualifying Test*

Sub-Test	Science versus Control	Mathematics versus Control
	t	t
English Usage	1.09	.82
Mathematics Usage	3.54**	4.28**
Social Studies Reading	1.23	.64
Natural Sciences Reading	2.50*	.25
Word Usage	2.63**	.49
Science Composite	2.35*	.10
Humanities Composite	3.12**	1.81
Total Composite	2.69**	.75

* Significant at the 5 per cent level.
** Significant at the 1 per cent level.
Degrees of freedom equal 198 in each case.

2. For the mathematics group versus the control group there were differences in the means as follows:
   a. English Usage test means showed that the mathematics group did not achieve significantly more than the control group in this area.
   b. Mathematics Usage test means showed that the mathematics group achieved significantly more than the control group (at the 1 per cent level) in this area.
   c. Social Studies Reading test means showed that the mathematics group did not achieve significantly more than the control group in this area.
   d. Natural Sciences Reading test means showed that the mathematics group did not achieve significantly more than the control group in this area.
   e. Word Usage test means showed that the mathematics group did not achieve significantly more than the control group in this area.
   f. Science Composite score means showed that the mathematics group did not achieve significantly more than the control group.
   g. Humanities Composite score means showed that the mathematics group did not achieve significantly more than the control group.

h. Total Composite score means showed that the mathematics group did not achieve significantly more than the control group.

TABLE 2

MEAN AND STANDARD DEVIATION FOR THE FIVE SUB-TEST AND COMPOSITE SCORES FOR THE SCIENCE GROUP ON THE *National Merit Scholarship Qualifying Test*

Sub-Test	$\overline{X}$	Standard Deviation
English Usage	18.87	4.60
Mathematics Usage	18.87	5.62
Social Studies Reading	19.73	5.02
Natural Sciences Reading	20.76	5.35
Word Usage	20.86	4.28
Science Composite	19.77	3.76
Humanities Composite	19.74	4.23
Total Composite	19.75	3.90

TABLE 3

MEAN AND STANDARD DEVIATION FOR THE FIVE SUB-TEST AND COMPOSITE SCORES FOR THE MATHEMATICS GROUP ON THE *National Merit Scholarship Qualifying Test*

Sub-Test	$\overline{X}$	Standard Deviation
English Usage	17.65	4.19
Mathematics Usage	19.72	6.44
Social Studies Reading	18.32	5.08
Natural Sciences Reading	19.06	5.98
Word Usage	18.75	4.96
Science Composite	18.49	4.10
Humanities Composite	19.03	4.69
Total Composite	18.64	4.27

TABLE 4

MEAN AND STANDARD DEVIATION FOR THE FIVE SUB-TEST AND COMPOSITE SCORES FOR THE CONTROL GROUP ON THE *National Merit Scholarship Qualifying Test*

Sub-Test	$\overline{X}$	Standard Deviation
English Usage	18.16	4.61
Mathematics Usage	16.04	5.67
Social Studies Reading	18.81	5.61
Natural Sciences Reading	18.86	5.39
Word Usage	19.10	5.12
Science Composite	18.43	4.26
Humanities Composite	17.87	4.32
Total Composite	18.19	4.24

As a result of the statistical analysis the null hypothesis under test was rejected for the following tests for the science group: Mathematics Usage, Natural Sciences Reading, Word Usage, Science Composite, Humanities Composite, and Total Composite. The null hypothesis was accepted for the following tests for the science group: English Usage and Social Studies Reading.

Concerning the results of the statistical analysis for the mathematics group versus the control group, the null hypothesis was rejected for only the Mathematics Usage test. The null hypothesis was accepted for the following tests: English Usage, Social Studies Reading, Natural Science Reading, Word Usage, Science Composite, Humanities Composite, and Total Composite.

Summary

From the analysis, it is possible to say that the statistically significant differences in means of the science group versus the control group lend support to the following statement: that having an inspirational science teacher favorably affects achievement as measured by the Mathematics Usage test, Natural Sciences Reading test, Word Usage test, Science Composite score, Humanities Composite score, and the Total Composite score. The last three areas indicate increased achievement in the overall areas of academic potential. Having an inspirational science teacher seemingly did not affect favorably achievement as measured by the English Usage test and the Social Studies Reading test.

The analysis also lends support to the following statement: that having an inspirational mathematics teacher favorably affects achievement as measured by the Mathematics Usage test and seemingly does not carry over as a favorable influence in any other area of academic achievement as measured by the *National Merit Scholarship Qualifying Test.* A fairly large t value occurred when the two groups were compared as to Humanities Composite scores but it was not statistically significant at the 5 per cent level.

During the period of time in which the writers were tabulating standard scores from the five sub-tests and the three composite scores on the *National Merit Scholarship Qualifying Test* for the science, mathematics, and control groups, several interesting trends were noted:

1. Students from small schools tended to mark non-science and non-mathematics subjects as being the areas in which they had an inspirational teacher. This tendency was probably due to the fact that very little science was offered in the schools in question and when offered the courses were alternated from year to year thus giving the students very little choice of

courses and many students did not take over one course in science.

2. Students in larger schools where more science courses were offered and there was specialization in the junior and senior years in physics or chemistry or in an advanced course in mathematics, tended to mark science or mathematics as the area in which they had an inspirational teacher.
3. In following through the responses of students from any one particular school, there was a tendency for the majority of students to mark a certain subject as being the area in which they had an inspirational teacher, thus tending to indicate that the particular teacher in question was outstanding in some respect.
4. As was expected, there was a much larger number of boys than girls who marked science or mathematics as the area in which they had an inspirational teacher since the girls tended to favor home economics or English.
5. In general there were more schools in which there was a variety of areas indicated for inspirational teaching than those in which one single course was noted. The tendency toward variety of answers might indicate that high school students are still in general not fully decided on a specific area of interest.

The results and summary statements given in the previous section of this report must be considered in light of the limited samples which were drawn for the comparisons. Also, the factor of intelligence was not considered since measures of it were not readily available. However, it is probably true that the students in the science and mathematics groups did not differ significantly in intelligence from the students in the control group. This fact, however, was not verified.

It is recognized that the present study has not clearly established, but only suggested: that teachers judged to be inspirational by their students are more effective in imparting academic facts and concepts to their students than teachers not so judged by their students. Undoubtedly, many factors other than the one considered in this study, were in operation to produce the differences obtained.

There was no attempt during the procedures followed in this study to establish criteria as to what constitutes inspirational teaching. Therefore it would be feasible to establish a tentative list of criteria concerning what constitutes this type of teaching. This list of criteria could then be submitted to the students who indicate they have an inspirational teacher. From the results of this, it would be possible through some sort of an analysis to determine which of the factors contribute the most to student achievement. Further study of the problem of achievement and the inspirational teacher should also include some attempts to determine what influence, if any, school size,

academic climate, and the number of science and mathematics courses offered, have on science achievement.

It may be implied from a review of literature that there is a definite need for a comprehensive nation-wide study of our secondary academic program in science and mathematics education in the United States. The writings of several authors recognize the importance of an adequate science and mathematics education program to the production of an adequate supply of well trained scientific personnel for all our national programs. Several writers also recognize the great need for an adequate supply of well-qualified teachers as they are an important factor in the problem of producing future scientists. The results of the statistical analysis presented in this study imply, that well-qualified teachers who know their subject matter and have the educational know-how to present their material effectively, can have a definite favorable influence on the achievement of students in science, mathematics, and other areas of academic achievement. Such inspirational teachers deserve the greatest admiration the teaching profession and lay public can give.

HEATING ROCKS GIVES NEW DATING METHOD

A new method of dating the age of past civilizations based on heating their rocks and pottery is now available to help the historian and archaeologist.

Thermoluminescence, caused by radioactivity in all sorts of materials and displayed when they are heated, is the basis of the new method.

The material, usually pottery or lava, is heated to below the point where it gives off light itself. This releases thermoluminescence, which is caused by electrons being freed from the solids in which they have been trapped for the many years.

All materials contain traces of radioactive elements. Over the years this radioactivity decays, giving off alpha and beta particles which trap electrons in solid crystals. The older the material, the more electrons are trapped.

When the material is heated up to about 350 degrees centigrade or less, the electrons are given back and create a mild light that can be captured by a photomultiplier tube. The more light, the older the material is.

The method is good for about 100,000 years in the past and it therefore supplements the dating of ancient civilizations by carbon isotope 14 which has been so successful for samples up to 40,000 years old.

The thermoluminescence method checked with the historical date. Lava rocks from northern Arizona were dated back to 15,000 years ago.

VITAMIN K SLOWS FOOD SPOILAGE

How vitamin K-5 keeps foods from spoiling is being studied here at Oregon State College. The vitamin, found naturally in green leafy vegetables, cheese, liver, egg yolk and tomatoes, is the only one known to kill organisms found in food. Also, unlike other vitamins, it is not destroyed by heat. This means it can be added with conventional canning and freezing methods. The vitamin may extend refrigerator shelf life of foods as much as six weeks after exposure to air. The U. S. Department of Public Health, Education and Welfare has awarded the College a grant of $23,667 to study the food preservation properties of vitamin K-5.

Historical Oddities Relating to the Number π

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There are many references which tell something of the historical development of the number π. Many of these are concerned with the gradual development of more accurate approximations, obtaining new expressions for the value of π, and the like. There are, however, some items less rarely mentioned, which might be said to have a certain historical interest, although perhaps not contributing to the development of any pure mathematics.

It has been pointed out[1] that the frequently encountered statement that the Egyptians used $(8d/9)^2$ as the area of a circle is technically not true, since the Egyptian number system used only unit fractions. More accurately, they subtracted one ninth of the diameter of a circle from the diameter, then squared the result.

Another common statement is that the Hebrews used the value $\pi = 3$, based on II Chronicles 4:2—"Also he made a molten sea of ten cubits from brim to brim, round in compass, and five cubits the height thereof; and a line of thirty cubits did compass it round about." One needs to use care here, the word 'round' does not necessarily mean circular. There is the distinct possibility that the top of this basin or sea was elliptical, ten cubits being the length of a minor axis.

The British "old wine gallon" still in use as the standard gallon in the United States was defined either as the content of a cylinder seven inches in diameter and six inches deep *or* as a volume of 231 cubic inches. It is interesting to note that the two definitions are equivalent if and only if the value of π is taken as exactly 22/7. It may be of interest to note that recently an engineering professor stated that until he entered college he was not aware of the fact that π was not an exact number with value 22/7.

The story of attempts to approximate the value of π is intriguing. Most students of the matter are aware that Archimedes essentially placed the value of π between $3\frac{1}{7}$ and $3\frac{10}{71}$, an approximation which is exact enough for most purposes. Mention might be made of Ludolph van Ceulen, a mathematician of Netherlands, who calculated π to 35 places. His accomplishment was considered so important that the value of π was included in the epitaph engraved on his tombstone. W. Hope Jones[2] tells of an interesting but futile attempt to find this stone, apparently no longer in existence.

[1] *Mathematics Teacher*, 43: 120–122.
[2] *Mathematical Gazette*, 22: 281–282.

Most histories of mathematics mention William Shanks and his accomplishment in computing π to 707 decimal places. It is by no means widely known that his value is incorrect beyond the 527th place. Shanks' result, published in 1873, is reported to have occupied him for more than 15 years (we hope not full time). Apparently no verification of this value was seriously attempted until in the period 1946–1948, when D. F. Ferguson and J. W. Wrench obtained an 808 place value of π, and called attention to the error in Shanks' value.[3] The 808 place value was verified, and the results extended to 2035 places using an electronic calculator, in 1949. The report mentions that the work was done on a week end, and occupied about 70 hours.[4] The contrast between the 70 hours and the 15 years attributed to Shanks seems immense. However, a later calculation (Some Comments on a NORC Computation of π)[5] gives the value of π to 3089 places, and is reported to have been accomplished with a machine time of *thirteen seconds*.

Perhaps we might close with mentioning, without any pride, a book of almost 300 pages, distributed *gratis* to many mathematicians and college libraries, devoted almost entirely to an attempted proof that $\pi = 313/81$. One of the several titles of the book is "The circle squared beyond refutation." But we should not be too critical. In 1897 House Bill No. 246 of the Indiana State Legislature passed the House, but because of some newspaper ridicule, was shelved by the Senate. The House first referred the bill to the Committee on Canals, then to the Committee on Education which recommended the passage of the bill; for some odd reason in the Senate it is reported to have been referred to the Committee on Temperance. The wording of the bill[6] is involved; the mathematics teacher or student might find it an interesting exercise to try to give it any meaning. Apparently Section 1 establishes the value of π as equal to four; Section 3 points out that three famous problems (tri-section of the angle, duplication of the cube, and quadrature of the circle) have been solved. Since the full text of the bill may not be readily available, it may be worth reproducing.

HOUSE BILL NO. 246

A bill for an act introducing a new mathematical truth and offered as a contribution to education to be used only by the state of Indiana free of cost by paying any royalties whatever on the same, provided it is accepted and adopted by the official action of the legislature of 1897.

SECTION 1. Be it enacted by the General Assembly of the state of Indiana, That it has been found that a circular area is to the square on a line equal to the

[3] *Mathematical Gazette*, 30: 89–90; *Mathematical Tables and Other Aids to Computation*, 2: 245–248

[4] *Mathematical Tables and Other Aids to Calculation*, 4: 11–15.

[5] *Mathematical Tables and Other Aids to Calculation*, 9: 162–164.

[6] *Mathematics Teacher*, 43: 120–122; *Atlantic Monthly*, 156: 118–119.

quadrant of the circumference as the area of an equilateral rectangle is to the square on one side. The diameter employed as the linear unit according to the present rule in computing the circle's area is entirely wrong, as it represents the circle's area one and one fifth times the area of a square whose perimeter is equal to the circumference of the circle. This is because one fifth of the diameter fails to be represented four times in the circle's circumference. For example, if we multiply the perimeter of a square by one fourth of any line one-fifth greater than one side, we can in like manner make the square's area to appear one-fifth greater than the fact, as is done by taking the diameter for the linear unit instead of the quadrant of the circle's circumference.

SECTION 2. It is impossible to compute the area of a circle on the diameter as the linear unit without trespassing upon the area outside of the circle to the extent of including one-fifth more area than is contained within the circle's circumference, because the square on the diameter produces the side of a square which equals nine when the arc of ninety degrees equals eight. By taking the quadrant of the circle's circumference for the linear unit, we fulfill the requirements of both quadrature and rectification of the circle's circumference. Furthermore, it has revealed the ratio of the chord and arc of ninety degrees, which is as seven to eight, and also the ratio of the diagonal and one side of a square which is as ten to seven, disclosing the fourth important fact, that the ratio of the diameter and circumference is as five-fourths to four; and because of these facts and the further fact that the rule in present use fails to work both ways mathematically, it should be discarded as wholly wanting and misleading in its practical applications.

SECTION 3. In further proof of the value of the author's proposed contribution to education, and offered as a gift to the State of Indiana, is the fact of his solutions of the trisection of the angle, duplication of the cube and quadrature of the circle having been already accepted as contributions to science by the *American Mathematical Monthly*, the leading exponent of mathematical thought in this country.

And be it remembered that these noted problems had been long since given up by scientific bodies as unsolvable mysteries and above man's ability to comprehend.

ONE SWALLOW OF LIVE VIRUS VACCINE PROTECTS AGAINST POLIO

One simple swallow of cherry-flavored syrup will give adequate protection against all three types of polio virus, seven American researchers reported.

The syrup contains types I, II, and III polio viruses that are very much alive. They are, however, too weak to cause paralyzing polio—they merely cause antibodies to be formed in the body.

The researchers are from the viral and rickettsial research section of Lederle Laboratories, Pearl River, N. Y. They reported the results of feeding the oral vaccine to 550 persons, mainly employees of the New York laboratory.

Tests before and after the persons swallowed the vaccine showed that good neutralizing antibody responses were formed in the 241 persons carefully checked. The remaining persons have not yet been checked.

Presently, only the Salk vaccine, made of killed viruses, is now backed by the health departments of both the U. S. and Great Britain. Persons must have three separate injections of Salk vaccine to receive immunization against the three types of polio virus.

Currently, the Lederle scientists have finished vaccinating 250,000 Costa Ricans with the tri-valent vaccine. They are now undertaking to vaccinate an additional 250,000. Results reported show that the vaccine is immunizing satisfactorily.

REVIEW OF RESEARCH IN SCIENCE EDUCATION

This group of seven articles is another in the series of reviews of science education research that has been published annually in SCHOOL SCIENCE AND MATHEMATICS. The reviews are presented each year at the annual convention of the American Association for the Advancement of Science. The program is planned by the National Association for Research in Science Teaching. This group of papers was presented at the AAAS Convention in Chicago, Illinois, December 28, 1959.

Research in Science Teaching at the Elementary Grade Level*

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In this review, sixteen studies related to the teaching of elementary science were examined. Of these, six were arbitrarily classified as Experimental, six as Analytical, and four as Synthetic.

EXPERIMENTAL STUDIES

Carpenter (E4) studied the effectiveness of elementary science instruction in Honolulu by comparing the "Problem Solving Method," based on demonstrations and experiments with the Textbook-Discussion Method. Three hundred twenty-three pupils in three nonpublic elementary schools were equated on the basis of intelligence, age and sex. Teachers were equated on the basis of education, experience, and rating by administrators. Two topics were selected for experimental use. They were MAGNETS and THE ADAPTATIONS OF ANIMALS. Each group of students studied one unit by the Problem Solving Method, the other by the Textbook-Discussion Method. Tests were then administered. In each instance, when the group utilized the Problem Solving Method, greater gains in achievement were recorded. Students ranking highest in scholastic ability were less influenced by the change in teaching methods than those ranking lower. When interviewed, most students and teachers expressed preference for the Problem Solving Method of teaching.

Hollenbeck (E5) surveyed the amounts and kinds of outdoor science experiences provided for Oregon children, both in schools and through other agencies. He then investigated the feasibility of pre-

* Members of the Elementary Science Committee: Nelson F. Beeler, Muriel Beuschlein, Donald Allen Boyer, Charles E. Burleson, Rose Lammel, G. Marion Young, and Betty L. Wheeler, Chairman.

senting outdoor science experiences at a school camp. He sent approximately 1,000 questionnaires to high school and college students. The replies indicated that, as elementary school children, they had little opportunity to participate in outdoor science experiences.

Plans were then made for the organization and administration of a pilot science school camp. Twenty-two fifth and sixth grade children were given opportunity for a one-week camp experience. Camp experiences included activities in the areas of conservation, geology, ornithology, forestry and aquatic biology. Hollenbeck's major conclusions included the following: 1) too little use had been made of available skilled resource personnel; 2) children gained from camp experiences: greater appreciation of ecological relationships, developed skills and knowledges related to outdoor living, and acquired new interests from camping; 3) the school camping project was practical and feasible and camp sites were available during the school year by using established summer camps.

A study similar to the one by Carpenter (E4) was that of Hubbell (E6) who compared the achievement of three groups of eighth graders when instructed by three different teaching techniques: 1) the textbook method; 2) the audio-visual method, using filmstrips; and 3) pupil-activity approach. The results indicated that students instructed by the pupil activity (or the project method) ranked highest. The students instructed by the audio-visual method, using filmstrips, ranked second, while those using the Textbook method ranked lowest.

Jackson (E7 and 8) in studies concerned with school gardening, evaluated student experiences resulting from gardening projects. Children in grades 6A and 7B who took part in summer gardening experiences were compared with one group who had had classroom instruction in gardening, and another group who had had no special instruction. The group participating in supervised summer gardening made greater gains in knowledge of gardening facts and in related biological concepts as compared to the other two groups. It should be noted, however, that the groups were selected on the basis of the availability of gardon plots in the area. No attempt was made to equate the groups with respect to learning ability, thus there was a wide range of abilities among the students participating in the study. A survey of the teachers involved in the project, indicated that they favored the school garden as a teaching tool and as a science laboratory.

Jones (E9) conducted a study of science instruction at the first grade level. For a period of one year, she recorded children's questions, responses and resulting decisions regarding science problems. She concluded that experimenting at the first grade level resulted in the growth of science concepts, skills and attitudes. She also con-

cluded that some of the concepts related to the child's environment that were developed within the experimental group were more advanced than those presented in most modern first grade science books.

Analytical Studies

Ashley (E1) helped develop a science program for the elementary grades in the Great Neck, New York area. The program was integrated with the total classroom program. Teachers were given aid from a consultant. Data for the program were obtained from the evaluation of existing science programs and from anecdotal records of children's experiences in science.

Blanc and Low (E2) reported on an analysis of science guides from thirteen larger school systems in the United States. All guides were dated since 1950. The investigators organized the contents of the guides into five major areas: Plants and Animals, Human Body, Earth, Universe, Matter and Energy. It should be noted that, despite the recency of the publications (since 1950), there was a definite dearth of "basic learnings" in the area of the human body and in the area of matter-energy. It should also be noted that little science is included at the kindergarten level. This report is a part of a continuing study being carried on by the K-12 Science Committee of the Denver Public School System.

Bryant (E3) conducted a study concerning the science understandings of importance for elementary children. These understandings were obtained from an analysis of twenty curriculum guides that were recommended by a Committee of the Association for Supervision and Curriculum Development. The science understandings for grades 1 through 6 were classified according to grade level, field of science, and environmental areas. Only understandings suggested by one-fifth or more of the guides were included. Specialists in various fields of science were then asked to group the understandings. The resulting 98 science understandings were then assumed to be of importance to the training of children and thus necessary in the science education of elementary-school teachers.

Analysis of the 20 guides showed little uniformity in either form or content. There was a tendency to emphasize physical science topics more than biological science topics at the upper elementary level. There was little agreement on specific grade placement of understandings.

This study also included an analysis of the science programs of 225 institutions belonging to the American Association of Colleges for Teacher Education. The analysis indicated that a mean of 17.7 quarter hours of science was required for elementary education majors. Biological and physical science survey courses and elementary

science methods were most frequently specified. Course content and instructional activities were generally determined by the instructor. It is interesting to note that college instructors of the required science courses are apparently as well prepared as college teachers in general, but over 75% of them have had no experience in teaching elementary-school children.

Kimes (E12) developed a Course of Study for Science Teaching in grades 1–8 in Maury County, Tennessee. The course of study included purposes, content, materials, activities, methods and evaluation techniques for science. In order the develop the outline, Kimes requested courses of study for grades 1–12 from thirteen State Departments of Education. Only five could furnish such a course of study. A teachers' committee then worked with the author in examining these course outlines. From this examination, purposes, content and suggested units for each grade level, were suggested.

In an attempt to evaluate the elementary science program and its effect on achievement in high school science courses, McLenden (E13) sent questionnaires to a group of teachers in the southeastern section of Georgia. The teachers selected were considered to be doing a creditable job of teaching elementary science. McLenden surveyed the backgrounds and training of these teachers, as well as the science units taught and methods and materials they used. The average length of teaching experience of the 47 participating teachers was 16½ years. The majority of the teachers had had field trips and/or laboratory experiences in college science courses. Twenty of the forty-seven had had summer workshop courses with some emphasis on science. Fifteen indicated no in-service or summer school science training. As a result of the study, the author concluded that a well-planned elementary science program would not only eliminate the necessity of general science in the first year of high school, but would improve the quality and level of science courses at the high school level.

Wong (E16) in Oakland, California, developed and tested techniques correlating classroom and field activities at the fifth and sixth grade levels. Science and social studies were integrated, with emphasis placed on conservation. Field trips were conducted. In addition, pupils were encouraged to participate in class discussions and record keeping. The author concluded that major concepts of science were broadened, that correlation with other areas of learning, particularly the language arts, were strengthened, and that because of the group participation in field trips, there was evidence of improvement in choice of leisure-time activities among the children involved.

Synthetic Studies

The purpose of study by Jones (E10) was to develop a source book of illustrative materials for teaching certain geological concepts. The

need for the study was based on the assumption that this is an area often lacking in the preparation of elementary teachers. The demonstrations selected were simple, and the needed materials were easily obtainable and inexpensive. The resulting book included such topics as Weathering, Erosion, Vulcanism, Mountain Making, Economic Geology. It includes a glossary of geological terms, and an appendix of maps.

Kerr (E11) conducted a study to determine the qualifications, functions and responsibilities of a consultant in elementary school science. This study covered a five-year period and was carried out in Gorham, Maine. However, the findings apply to further school-community relationships; ability to build rapport among teachers within a school and within a school system, ability to organize an in-service program. Characteristics relating specifically to elementary science were: possession of a good background in science; ability to evaluate the science experiences of children in relation to educational values and behaviors; ability to see science in relation to the total curriculum; knowledge of instructional materials and equipment for science; knowledge of types, sources, use, care and storage of these materials; and knowledge of community resources.

Reiner (E14 and 15) has been responsible for two studies evaluating the effectiveness of a television series in improving the elementary science teaching program. The first study involved eight telecasts aimed at kindergarten-grade two; the second study was a series of thirteen telecasts based on the "Science Corner" and was intended for grades three and four. Both series of telecasts were evaluated by the participating teachers who rated the programs on the basis of the following criteria: interest of children watching the programs; pace of programs; appropriateness of subject matter for grade level; appropriateness of vocabulary; effectiveness of experiments in illustrating principles involved; usefulness of the telecast to the teaching program; effectiveness of pre-program questions in a provided manual; and suggestions of additional activities by the program. The results of the study indicated the value of the programs in achieving the desired aims.

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Implications of the Findings of Recent Research in Elementary Science Education

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There are several important reasons for teaching science to children in the elementary school. These include "science for fun," science for hobbies, science as a motivation for better learning of other subjects, and science to help children develop an appreciation of the universe of nature. But there are more basic reasons (reasons which do not exclude the above) that derive from *what science is:* man's continuing search for truth about the universe. In "universe" we have an indication of the range of possible explorations by scientists and by children as they investigate. In "truth" we have the notion of verifiable knowledge, knowledge that can be checked by others, knowledge that under present conditions, using our best available instruments of observation, seems to "hold water." To help children learn these "truths" in the form of principles, generalizations, and concepts is perhaps the basic purpose for teaching science.

But in our definition we also have the word "search." In "search" we are reminded that science involves the processes of inquiry, that science takes place when people are investigating, searching, probing, experimenting, exploring, thinking, reasoning, and analyzing. In the search, scientists are ever refining the ***descriptions*** of the universe, are developing better and better ***explanations*** of how things happen and are making predictions based on descriptions and explanations. In science teaching we seek ways to provide children with opportunities to do these things. It is in this framework that we identify another basic purpose for teaching science, namely to help children learn how to investigate, how to inquire, how, in effect, to behave like scientists. It is our present best hunch that children learn science-like behaviors and skills by seeking answers to questions in an atmosphere where scientific behaviors and methods are both expected and planned for, recognizing that the methods and behaviors must be appropriate to gradually maturing children.

It is reasonable then to expect that much of the research in elementary science relates to the two basic questions: (1) How can children best learn the content (concepts) of science and (2) how can they learn the methods of science? Several of the studies reported this year bear on these major questions. For example, Carpenter (E4) in comparing the "problem-solving" method to the "textbook-discussion" method, reports that when the group utilized the problem-solving method, higher test results were noted. And Hollenbeck (E5) re-

ported, among other things, that children who had outdoor science experiences at camp gained much in their appreciations of ecological relationships and in their skills and knowledges relating to outdoor living. Hubbell (E6) concluded that the pupil activity (or project method) ranked highest in bringing about pupil achievement compared to other methods tested (one highlighting the use of filmstrips and one highlighting the use of textbooks). And Jackson (E7 and E8) compared the achievement of a group involved in a summer gardening experience with a group that originally studied in class about gardening and another group with no preparation, study or experiences in gardening. The group participating in the supervised summer gardening not only gained more gardening facts but also more related biological concepts than the other groups.

In these studies we have substantial support for the belief that involving children in purposeful activity and problem solving situations enables them not only to learn more content but also to be scientific in ways that develop the skills of inquiry effectively.

All learning involves change or adjustment, and children learn best (as do all people) when there is a suitable and optimum motivation for learning. Teachers generally wish to know how to involve children in ways to increase the quantity and quality of learning. In recent years much psychological experimentation and research has sought information on ways to bring about improvement of learning. These studies point to certain generalizations about learning which certainly should be incorporated into the thinking and planning of science teachers as they work with children.

One generalization seems particularly significant: No single factor ever operates to influence learning. Rather, innumerable factors interact in the learning process. Of particular importance is the nature of each child—built upon or influenced by his home background, present physiological condition, his degree of success or failure in learning, degree of genuine self-confidence, self assurance, self-reliance, and other such factors. The recent studies in elementary science have given support to some of these generalizations and have shown that they apply more specifically in the area of science. The science teacher and consultant must recognize these differences and their relationships to the motivation and learning of each child. Kerr's study (E11), for example, of the qualifications of a science consultant concludes that a knowledge of these kinds of interrelationships is essential to being a successful consultant. Kerr also points out that a successful consultant must see the relationship of science to the total curriculum. It seems safe to assume that the teacher of science, also, should understand this relationship.

In the face of a trend in some schools to divorce science teaching

from other related experiences in the child's school-day experiences, Wong (E16) has demonstrated how in a correlated classroom and field activity program both science and social studies concepts were strengthened. He affirms that as science concepts are broadened, learnings in the language arts and other areas of experience are broadened. There continue to be dedicated individuals and groups who believe that, in the face of pressures to teach "more and better science," we must not divorce the science experiences of children from the other aspects of their school program. There are many sound reasons why this position should be encouraged.

The important work of determining what constitutes a good elementary science program continues. Some of the studies (Ashley, E1, Blanc and Low, E2, and Kimes, E12) identify suitable areas for study throughout the elementary grades. Others (Bryant, E3) seek to identify the range of concepts or understandings that should be taught. Another (Jones, E10) identifies the concepts to be taught in selected areas of meteorology and geology. For the most part, these studies identify content for a particular school system rather than for universal acceptance. Bryant's (E3) and Jones' (E10) studies of concepts were aimed at providing guidance in the preparation of teachers or resource material for teachers. Studies show also that learning is at a maximum when each teacher and learner clearly understands and accepts the purposes. For best learning it follows, then, that the teachers must consciously keep in mind the purposes to be achieved and help children understand these purposes. Further, teaching must be done in ways that lead to the achievement of the purposes. A fine example of this is implicit in "A Study of the Possible Learnings Resulting from Science Experimentation by a Class of First Grade Children" reported by Mary Elliott Jones (E9) or see *Science Education*, Vol. 43, 335–74. Here the investigator-teacher consciously provided opportunities for children to experiment to develop skills, attitudes, and concepts consistent with scientific knowledge and methods. In this atmosphere of expectation children did indeed grow.

In conclusion, studies seem to show that involving children in activity-type science programs helps them learn more science facts and concepts than in a limited reading or non-activity type of program. In the activity-type program children, with purposes continually being clarified, learn the skills and attitudes of sound inquiry associated with science. Though studies do not show that there is only one way to learn science, they continue to confirm that children must have opportunities to explore, to investigate, to "be like" scientists, if our goals are to be achieved. Therefore, teachers must be inventive, ingenious, and imaginative in incorporating real inquiry as an essential ingredient in the science experiences which children have.

Studies in Science Education for 1958–1959: The Secondary School

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The scope of this review of research related to secondary school science education is limited to a selected group of studies either published between July 1958 and July 1959 or reported to the Office of Education in the form of abstracts during the same period. Criteria for selecting studies for inclusion in this review were contained in a memorandum prepared in the Office of Education and may be obtained by those interested.[1] It should be pointed out that the studies available for review did not include all the studies completed during the period noted above; for example, of the 35 doctoral dissertations in science education listed in *Research Studies in Education, 1958*,[2] only 13 were available for review in the biennial summary for 1957–59.

The studies reported here were classified in three broad groups: (1) studies related to developing the teaching fields, (2) studies related to the status, problems, and training of teachers, and (3) studies related to learning, interests, and attitudes. These categories, of course, have no intended significance other than convenience in reporting.

Developing the Teaching Fields

By a teaching field in science education is meant the complex of decisions and activities which a teacher undertakes in order to develop a systematic course in a given field such as chemistry or general science. It is inclusive of the many problems characteristically related to the perennial questions of what to teach and how to teach it. As it is generally agreed that the major responsibility of the science teacher is the cultivation and improvement of his teaching field, the kind and quality of studies in this area are of special interest.

As expected, several studies were concerned with content and its organization for teaching purposes. Stone (42) and Pierce (29), with the help of a group of interested teachers, worked out rather elaborate courses of study in biology and chemistry respectively, which stressed the inclusion of new findings from scientific investigations and the conceptual unity of each of the two fields. Post (31) developed a

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[1] Dr. Ellsworth S. Obourn, Office of Education, Department of Health, Education and Welfare, Washington 25, D. C.

[2] Elam, Stanley, editor, *Research Studies in Education*. Bloomington, Indiana. Phi Delta Kappa, Inc., 1959.

source book for teachers of biology and general science containing recent information on the nature and control of rodents in American communities. Field studies and teaching materials in marine biology and earth science were stressed in comprehensive studies by Flora (10) and Bareham (2). Both studies are rich in suggestions for field and laboratory work, and for materials which could be incorporated in secondary school science programs.

The relationship of standard content in seventh grade general science to the purposes of the junior high school was investigated by Crocker (8). Using a modified jury technique, he concluded that topics commonly found in general science courses of study and texts contributed in some degree to the purposes of the junior high school. A comparison of current objectives and content in high school biology with those prevailing forty and eighty years ago was reported by Howard (19). He found that purely factual information objectives were largely replaced during the period studied by functional information objectives and that mental discipline and religious objectives had disappeared from current texts and courses of study in high school biology. In an investigation of the advantages and disadvantages of offering biology at the ninth grade and physical science at the tenth grade in two schools, Heidgerd (18), reported that achievement in biology for ninth grade groups was somewhat inferior to that in the schools where biology was taught in the tenth grade, but when adjustment was made for mental age, achievement was about as good as would be predicted. Achievement in physical science was found to be high in the experimental groups. In a comprehensive study of the sex-education of twelve year old boys, covering a 30 year period, Goudy (15) found that a "chum" is a more important source of sex information for the early adolescent than either parent or teacher and concluded that the sex education of children should begin early, should be continuous, and should be given by parents, teachers, and possibly other adults who have a more or less formal relation to children. Munzer (25) analyzed curricula and texts to determine what schools were teaching about conservation and in a questionnaire study found that teachers were somewhat confused on the question of conservation education due in part to the prevalence of an outdated concept of conservation.

The relevance of educational research to problems in science education is generally recognized by science educators. The difficulty has been to implement the findings of research. As a way to overcome this difficulty, it has been often proposed that the classroom teacher undertake to develop a research oriented classroom by engaging in systematic action or classroom research projects. In this context studies reported by Pugno (32), Oakes (28), Lowry (24), Nelson (27),

Gunkle (17), and Smith (39) are pertinent. Pugno produced a guide to classroom research for science teachers including the philosophy and theory of action research, the skills and techniques needed to design and carry out action research projects, and many illustrations of research problems which could be undertaken by the average classroom teacher. In an interesting proposal Oakes reported a plan for an action research project designed to overcome teleological and anthropomorphic thinking in high school biology classes. Experiences with a tenth grade physical science course were studied in an action research framework by Lowry, and Nelson reported on the development of a test to measure attainment of objectives that involve more than memorization of facts. Gunkle, investigating two methods of teaching the gas law to his classes, concluded that the groups taught to reason out problems from the given data achieved greater understanding and retention than comparable groups taught by the formula method. In a somewhat different type of action research, Smith studied the educational potential of a vacant city lot over a period of time and found that such a situation did contain many illustrations of important biological principles.

The activities of science supervisors and state agencies, and surveys of curricular and teaching practices, attracted a few investigators during the period under review. Using survey, jury, and statistical techniques, Lee (23) investigated the relationship between the rank order of importance of supervisory activities as judged by a jury of experts, and the actual practices reported by a selected group of state and local science supervisors. The correlation between the jury rankings and frequency of practice were moderate for both state and local supervisors. Interestingly, the category with the lowest ranking in practice was research. In a study of conservation education leadership among state agencies for the period 1956–58, Weaver (47) found that 30 states had fairly adequate programs for assisting schools in conservation education; for example, 28 states had some type of teaching guide and nine states had some form of legislation dealing with conservation education. Analyzing official records and using direct observational techniques, Voss (46) investigated trends in curriculum development, methods of instruction, facilities, and the status of teachers in science education in the high schools of Iowa. Most of the teachers observed used a single textbook and most common classroom activity was recitation. About 40 per cent of the Iowa teachers studied had four or more preparations daily. The most common problems noted by the science teachers were lack of facilities and equipment, time, and the omnipresent individual differences among students. Interesting light was thrown on teaching and curriculum practices in a study reported by Kruglak (22). He inferred, from the

responses of college freshman physics students to a questionnaire, that the good high school physics course as viewed by the freshman students was characterized by frequent and regular laboratory work, frequent and regular demonstrations, regular homework assignments in substantial amounts, rigorous grading standards, and by a strong interest of the instructor in the teaching of physics. Contained in a report of a special conference, edited by Stanley, Brody, and Burnett (41), were many important suggestions for the improvement of science teaching in the schools.

To conclude this section we may take note of two studies on course offerings and enrollments. Shaun (37), using data submitted by high school principals, found that course offerings and enrollments in Idaho high schools compared favorably with national averages. Analyzing data from a 10 per cent random sample of the nation's high schools, Brown (5) determined that substantial numbers of high schools (presumably, mostly small) did not regularly offer courses in physics, chemistry, algebra, trigonometry, or solid geometry.

Teacher Status, Problems, and Training

The classroom teacher has always enjoyed preferential status as an object of concern and often as a subject for research. This is understandable in the light of the key position of the teacher in formal educational programs. His training, his general competence, his aptitude for teaching, and his attitudes toward society, and even his attitudes toward science and science teaching have been investigated by the researcher from time to time. Employing a questionnaire containing 50 specially prepared statements, Benke (3) studied the opinions of a randomly selected group of 621 science teachers with respect to certain issues and problems in science and science teaching and compared their responses with the responses of a selected group of 70 prominent working scientists. Item analysis revealed marked differences between the teachers and scientists on many responses, especially those related to the nature of science and science teaching. On the other hand, little or no differences in responses were found between subgroups of teachers separated out on the basis of such factors as amount of course work in science and in education, type of college or university attended, and length of teaching experience. Investigating the competencies needed by secondary school teachers, Spore (40) devised a rating scale composed of 60 competencies derived from the literature in science education and submitted the rating scale to four groups of judges who were asked to rate each competency as to its importance on a five point scale and to indicate at what point in the training program of teachers the various competencies should be emphasized. Differences among the four groups of judges were found;

the science teachers and school administrators were in closest agreement and the foundation educators and science educators were farthest apart in their judgments on the relative importance of the various competencies. The four groups of judges were found to be in general agreement that the competencies listed should receive equal emphasis in the education of science teachers.

The academic and teaching backgrounds of secondary school science teachers in Ohio were studied by Koelsche (21). He found that the typical Ohio science teacher was a graduate of an Ohio institution of higher education, had pursued some in-service graduate work, had a four-year provisional teaching certificate, and had approximately 11 years of teaching experience. In a similar study in the same state, Gardner (12) found that although the majority of teachers included in the study had graduate credits, significant deficiencies were discovered when the academic preparation of the teacher was compared with recommended undergraduate standards for science teaching majors. She concluded that the widespread existence of teaching combinations of two or more sciences indicated the need for teachers to acquire broad science backgrounds. Investigating the teaching loads of science teachers in the state of Oregon, Thaw (44) ascertained that science teachers have relatively little free time during the school day and spent up to 21 or more hours weekly on preparations for classwork and extra-curricular activities. The daily preparations for these same teachers ranged from one to six with the median between two and three preparations daily.

The problems and in-service training needs of science teachers are of considerable importance. Using questionnaires administered to science teachers and high school principals, Gruener (16) found that major sources of problems of science teachers in the Philadelphia area were related to facilities, supplies and equipment, extra-classroom demands, working conditions, individual differences of pupils, and especially, effective direction of learning. Victor (45) investigated the help and assistance beginning science teachers think they need by means of a questionnaire administered to two groups of randomly selected beginning science teachers in Massachusetts, one with and the other without adequate training in science. Both groups indicated need for help with respect to all the included 21 practices commonly associated with science teaching. In an evaluation study of the summer institutes attended by science and mathematics teachers from New York City high schools, Schenberg (34) reported that the teachers attending these institutes found them extremely valuable, interesting, and stimulating. On the other hand, these same teachers felt that the institutes covered too much ground, required too much homework, neglected the problem of articulating the work of the in-

stitute with high school courses, and failed to provide adequate time for the exchange of ideas among the attending teachers. Summer employment is of interest and importance to science teachers as well as in-service institutes. Goodin (14) investigated summer employment opportunities for science teachers in southwestern United States. He concluded on the basis of information obtained from 100 industrial concerns that in general business and industry were aware of, and sympathetic with the need of science teachers for constructive summer work, and that there exist many opportunities in the southwestern states for science teachers to obtain profitable summer employment.

Two studies by Myers and Crall (7, 26) merit attention. The first of these studies dealt with recommendations for improving the preservice programs for the training of high school biology teachers and the second stressed recommendations for training "master teachers" for high school biology at the Master's degree, or higher graduate level.

Learning, Interests, and Attitudes

A substantial portion of the studies reviewed were related in one way or another to learning, interests, and attitudes. This was thought to be significant as such studies are of great importance in giving direction to the creation of effective science education programs. Frankel (11) investigated causes for the differences in scholastic performance of achieving and underachieving boys of equivalent intellectual ability at the Bronx High School of Science. He showed that the achievers demonstrated greater aptitude in the verbal and mathematical areas and greater interest in mathematics and science than was true for the underachievers. As a group, the boys with poor achievement records expressed more negative feelings toward school in terms of less participation in extracurricular activities, poorer attendance, and more disciplinary offences than was found for the comparable group who were doing well in their school studies. In a comparison of the inductive and deductive methods of teaching high school chemistry involving a relatively large group of students and teachers, Sister Ernestine Marie (38) found that inductively taught classes showed significant superiority in achievement over deductively taught classes with respect to the year's work, and to a special unit on the balancing of chemical equations. Using analysis of variance and the Chi-square test of normality, Porter and Anderson (30) studied the Achievement in chemistry of a selected group of students in order to determine the relationship of specified abilities in chemistry to each other and to intelligence. They discovered that while there was a consistent decrease in overall achievement as measured by a standard-

ized test from the top intellectual group to the lowest, this did not always hold true when the same groups were compared on the basis of their achievement on specific abilities identified in the test used.

For many reasons, there has been an accelerated emphasis on the use of teaching aids in science education during the past decade, particularly the motion picture and television. While there is no comparable development in studying the effectiveness of these media in science education, a few studies were reported during the period under review. Garside (13), working with 60 physics classes in Wisconsin, made a comprehensive study of the influence of the "White physics films" on learning in mechanics and heat. He found that the level of achievement of students of high and low intelligence respectively in the experimental (film) group was not significantly different from that of comparable students in the control (non-film) group but there was a significant difference in level of retention favoring the control group. In a study of the effect of a special motion picture on the learning of biological principles related to the control of poliomyelitis and on attitudes toward the National Foundation of Infantile Paralysis and the March of Dimes, Bichler (4) found that the use of the fim produced no significant difference in changed understandings and attitudes from those achieved in comparable groups where the film was not used. Schuman (36) investigated the relative effects of positive and negative introductory sequences inserted in a selected instructional film on the immediate and delayed recall of factual information learned from the film by two similar groups of ninth grade general science pupils. By means of appropriate testing techniques, he discovered that the group viewing the film with positive introductory sequence did better on immediate recall tests than those groups viewing the film with the negative introductory sequence. On delayed recall tests, the relative achievement of the groups was reversed. Students with average intelligence (the middle group) profited most from the film irrespective of type of introduction. Swoveland (43) reported that students in television courses in mathematics, physics, and geology felt keenly the absence of personal contact with a teacher, and Brown (6) found no difference in achievement of ninth grade groups taught a unit on aviation with the aid of mechanical teaching devices when compared with similar groups taught the same unit without such aids.

In a comprehensive study of the attitudes of high school seniors toward science and scientific careers, Allen (1) showed that for the group studied the overall picture of attitudes was favorable and constructive toward science when judged by the response ratings determined by a jury. On the other hand, an item analysis of all responses revealed the existence of misunderstanding on the part of many stu-

dents on questions related to the scientist and his work, and to the nature of science. Intelligence was found to be related to the character of the responses; the greater the intelligence of a given senior, the greater the chances he would have favorable attitudes toward science. In the same area Schmidt (35) developed an instrument for measuring secondary school student attitudes toward science and established its reliability and validity by administering it to a large group of junior and senior high school students. As a by-product, Schmidt discovered that the twelfth grade students included in the study had less positive attitudes towards science than was true for the eighth grade group.

Factors which influence science related interests and choices of secondary school students are important to science educators. Hutchins (20) in a questionnaire study of the science interests of a large group of high school students in North Carolina found that the most important factor which influenced student interest in science was the teacher and that the most common reasons cited by students for disliking science were difficulty of science subjects, poorly trained teachers and poor teaching. In a follow-up study of a sample of the finalists in the first four national science fairs, Requa (33) discovered that over 80 per cent of the group returning questionnaires were in scientific positions or training for such jobs and concluded that science fairs had sufficient educational value to merit additional emphasis in school science programs. The rewards program of the Future Scientists of America was studied by Fisk (9) by means of a questionnaire sent to teachers and students involved in the program. He found that the teachers in the program were well educated, were members of several professional organizations and were in the larger schools. Students in the winner and honorable mention groups seemed to have similar characteristics: they had well educated parents, had worked out college plans, indicated scientific career intentions, and they held a large number of offices in high school organizations. Girls were represented by relatively small numbers in both groups.

Summary

The studies reviewed in this paper covered a fairly wide range of subjects but leave something to be desired in new findings and new light on the research process. In this regard, research in science education seems to be no better or no worse than in the other subject areas. Well known dogma and doctrine still remain largely unchallenged and only a few of the studies reported here involved hypotheses derived from educational theory to guide the research undertaken. The fact finding, the status-survey, the descriptive types of

studies, and the assembling and reassembling of teaching materials while decidely useful and often necessary, are hardly more than the routine kinds of research every institutionalized endeavor engages in from time to time. It must be admitted that we hardly know more about what is good science teaching today than we did fifty years ago, not only from the standpoint of science but also from the standpoint of the individual and society.

It is legitimate in this context to raise again the question of why this should be so. Are the universities with their graduate schools and departments of education, and the colleges of education to blame? Are the high school teachers culpable on this score? Or is it that the whole educational enterprise is non-research oriented? We can hardly blame the high school teachers. What institution requires and provides systematic training in the theory and practice of educational research even at the master's or doctoral levels? What state requires understandings and skills in research as a condition for the certification of science or other teachers?

Nor should we lodge all the blame at the door of the graduate school or the college of education, although it is clear that institutions of higher learning should contribute substantially to educational research and should provide some of the needed leadership. But what graduate school or college of education or liberal arts college is oriented and properly geared for systematic and creative research in education? Outside the relatively small group in education, the vast majority of professors in graduate schools and colleges are not interested in educational research even when they are directly involved in teaching. And, as in other areas, educational research is expensive, no matter how you view it. Far too many of the studies associated with graduate programs are necessarily cheap in time, energy, out-of-pocket money and sometimes, in the understandings and skills needed to carry on the research. It should surprise no one that many such studies have made only minor contributions to education.

It is suggested that the basic difficulty lies in our inadequate conception of the educational process which over the years has tended more and more to be narrow rather than broad, static rather than dynamic. We have been long on goals, even creative, but short on adequate policies to achieve the goals. It is at the level of policies that we need appropriate research to inform and test our policy making and to develop action programs to implement what we find out and what we already know. Far too many problems in science education are neglected, or left to chance, or simply referred to tradition for solution. Almost never are the basic problems in science education the subject of systematic and continuous research directed to the formulation and implementation of intelligent choices in the classroom

and elsewhere. Indeed, there are many in and out of education who feel that the methods of research are not applicable to educational problems. The only way to get out, and keep out, of this vicious circle is to apply our individual and collective intelligence to the problems at hand and this inevitably means organized and systematic research, both formal and informal, at all levels of the educational enterprise. Unless we do so, our educational theory will remain uncultivated, our goals will deteriorate, and our practices will stagnate.

To conclude on a positive note, we may first recognize the endemic confusion in the field of research in science education and then briefly suggest a possibility for bringing such research in line with the pressing problems in the current dynamic scientific and social scene. To overcome the present lack of focus in present research efforts, and to raise the level of research in science education beyond the natural history stage of development, it is suggested that the teaching societies associated with the AAAS, including the NARST, take the lead in establishing a cooperative council for research in science education.

Such a council, if properly developed, could attract support, financial and otherwise, not only from the membership of the teaching societies but also from the AAAS and one or more of the various foundations with an interest in science education. In addition, able and interested professional workers in education, sociology, psychology, anthropology and the biological and physical sciences might be associated directly with the council and thus bring relevant findings in these various disciplines to bear on problems in science education as well as involving these professionals directly in the formulation of research policies and programs. While this is not the place for sketching out the details of such a council, or to make a special plea, it may be strongly urged that the officers of the NARST undertake to investigate the possibilities for such an organization as is indicated above. It is believed that only by means of such a potentially creative, cooperative operation can we rescue research in science education from the slough where it is presently mired.

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Implications of the Findings of Recent Research in Secondary-School Science Education

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Discussing the implications of research is a form of self-criticism freely indulged in by the fraternity of producers and consumers of research in secondary school science education. The ground rules require that omissions as well as commissions be noted and commented upon in an objective manner, without carping or caviling.

The implications of research are derived from an examination of the studies very capably and carefully reported by Professor Hubert Evans. Additional implications will be derived from an analysis of several questions as:

A—Who is doing research?
B—What do we expect from research?
C—How has research been meeting and beating the four menaces?
D—What new approaches should be explored?
E—From whence shall research leadership come?

Implications from the Reported Studies

Professor Evans has reported about fifty studies which deal with curriculum; methodology; pupil traits and achievements; status, problems, and training of teachers; and learning, interest, and attitudes of pupils. The number of studies in the secondary field is greater than that reported in the past two years. It can also be said that in general, the quality of these reports indicates improvement in regard to the skill with which research techniques have been utilized. It is not within the scope of this report to criticize the technical competence of individual studies. However, on the whole, they were well executed.

In viewing the body of research summarized by Professor Evans certain conclusions were reached in which he and the writer were in agreement. These were as follows:

1. There were more studies dealing with content but fewer concerned with methods of teaching.
2. Many gaps exist in research in worthwhile areas needing investigation.
3. There was too little of the classroom type of research.
4. There was an absence of investigations in which accepted theories of learning were applied to determine the extent to which they brought about changes in pupils in classrooms.
5. There is a lag in the application of earlier research findings to present practice.
6. Many studies mentioned in the literature were not available to the committee which was responsible for summarizing them.
7. There was an absence of clear-cut attention to research techniques in many of the reported studies.

As stated earlier these criticisms are intended as constructive suggestions, not deprecations, to guide our colleagues.

A. Who Is Doing the Research?

A listing of the groups engaged in research is presented below. It is fairly evident that certain types of studies are more likely to emanate from certain sources. For example, government agencies issue status studies on pupil populations, salaries, and school facilities, whereas college-sponsored groups are more likely to be concerned with learning, pupil traits, or methods of teaching.

A brief list of groups engaged in research activities follows.

1. Colleges and Universities
   (a) research bureaus and services
   (b) graduate students working for degrees under faculty guidance
   (c) faculty members engaged in research under grants or independently
2. Government Agencies
   (a) Federal, i.e., Office of Education
   (b) State, i.e., Bureau of Curriculum Research
   (c) City—school systems having research bureaus
   (d) County—research responsibilities
3. Professional Organizations
   (a) National Association for Research in Education
   (b) American Association for the Advancement of Science
   (c) National Science Teachers' Association
   (d) Regional organizations having research committees, and other groups
4. Foundations and Endowed Groups as the Rockefeller Brothers Fund, Ford Foundation, Conservation Foundation, and numerous others
5. Action Research Groups
   These are teachers-on-the-job who are cooperating in a research project under the guidance of a trained research worker. (Pugno's study, mentioned by Professor Evans is of special interest in this connection.)

The quantity and quality of research from the above groups varies because of differences in trained personnel, resources, and goals prevalent among them. The limitations in time and training among college students usually results in studies of small scope. Professional organizations work in fields closest to their interests. What is most evident is the lack of a general pattern of research on the part of all groups. Many problems are repeatedly investigated while others are neglected. This results in waste and lost opportunities which leadership and direction could correct, if properly applied.

B. What Do We Expect from Research?

Research is expected to produce answers to the important questions of "what to teach" and "what is the best way to get the best results." Research should be technically competent so that confidence may be placed in it. This, of course, is an oversimplification but it conveys the main idea.

Quite a few basic problems need to be solved before the above

questions can be answered. These problems are listed below and suggest areas in which research is needed.

Needed Areas of Research

1. Philosophic, psychologic, and social foundations of the secondary school science curriculum
2. What to teach or the courses of study
3. How to improve teaching techniques
4. The development and use of audio-visual aids, reading matter, demonstration materials, buildings, classroom design, and equipment
5. How to supervise and administer a program
6. The application of principles of group dynamics and social interaction in relation to teachers, pupils, and communities
7. Pupil traits and learning patterns
8. The mechanics and process of concept development
9. Teacher characteristics related to their training and functioning
10. Refinement of techniques used to evaluate higher thought processes and attitudes

Some of the reported studies deal with curriculum problems, teacher training, and pupil traits. However, the absence of investigations dealing with other crucial areas points to the need for a broader base of research. This can be attained by planning and cooperation among research groups.

Desirable Criteria of Competence in Research

1) Clear statement of the scope and depth of the problem studied
2) High potential of applicability of the findings toward increased effectiveness of teaching and learning (Avoid trivial or "straw-man" problems)
3) Employment of an appropriate research design
4) Use of proper sampling techniques in selecting the populations or data to be studied
5) Development and/or application of valid, reliable, practical evaluation instruments
6) Application of statistical techniques which analyze in sufficient detail and which indicate the degree of confidence which may be placed in the differences or other relationships determined
7) Drawing of sound and valid conclusions from the data and properly identifying inferences drawn from extrapolated data
8) Offering recommendations which are drawn from research conclusions and seem to be reasonable, applicable, and functional

Past surveys of research have revealed a need for greater technical competence in the criteria mentioned above. The level of technical excellence varies with the group sponsoring the investigation. Doctoral dissertations and foundation sponsored studies are well constructed. Many Master's Degree theses and independent studies have been criticized in the past for their weaknesses in the criteria mentioned.

C. How Has Research Been Meeting and Beating the Four Menaces?

The public has learned through the press and other mass media of

communication about the menace posed by Russian advances in space science and technology. Other menaces which have caused concern and debate are the replacement of teachers by television, the threatened obsolescence of schools by means of the learning machine, and the disappearance of science education in the abyss of the liberal arts program. Let us examine each menace in terms of what research has found out about it and also in terms of what research points to in the future.

1. *The Russian Menace.* An elementary principle in curriculum development states that the curriculum should be derived from the philosophic, social, and psychological foundations of a nation. Shall we then scuttle our democratic philosophy and social system in panic and convert our science courses into space training institutes? Research has the weapon to slay this dragon. Status studies by Koelsche, Gruener, Myers, Crall, Voss, and Shaun, indicate that our weaknesses lie in our teacher training, poor working conditions, poor salaries, and inadequate equipment. Let us improve what we have. To paraphrase a passage from Shakespeare's Julius Caeser, "The fault dear Brutus is not in our stars but within ourselves." We need not scuttle our system or look for magic panaceas. We know what has to be done and we must be willing to spend the money and make the effort.

2. *The Television Menace.* Some educators fear that television will replace the teacher. Swoveland's study, reported previously by Professor Evans and reports from other sources should allay these fears. In New York City parents and pupils felt that a television physics course could not do what a live teacher could do in a classroom. As reported in Swoveland's study, they felt keenly the absence of personal contact. It is doubtful that the dictating machine and typewriter will replace the stenographer who also answers the telephone and reminds her boss that it is his wife's birthday. Research findings indicate that television is an effective aid for enrichment, for supplementary and cooperative teaching, for teacher training, and for bringing special events to the classroom. It is misleading to think that television instruction is cheaper than hiring teachers. Studies of TV station capital investment and operations costs support this view.

3. *The Learning Machine Menace.* Press releases have implied that learning machines may some day replace teachers and that schools will be changed in character. Research shows that these machines are practical and that they can convey information and check on pupil mastery. Will they work well in early childhood grades? Can they inspire pupils? Hutchins' study, reported by Professor Evans, found that the most important factor which in-

fluenced student interest in science was the teacher. Other studies corroborate this. The writer read a letter written by a recent Nobel Prize winner to his former teacher in which he thanked him for kindling his earliest interest in genetics. Research points to a fruitful future for learning machines. One promising avenue, other than its use as a study aid, is as a laboratory tool in studying learning behavior and pupil characteristics. We have used observational techniques quite commonly but here is a device that can isolate a single pupil, eliminate many distracting variables, and lends itself to objective replication. It holds promise in investigations of concept formation and growth. The learning machine is another example of how a technological advance multiplies rather than diminishes opportunities for employment.

4. *The Liberal Arts Menace.* Some science educators have espoused the idea of treating science education as a part of the liberal arts tradition. Others consider this as a menace to the continued existence of science as an independent curriculum subject. Curricula have been reported and evaluated which have had the problem solving approach; the vocational, applicational, or technological approach; the historical- economic-social uses approach; and various combinations of these. Research seems to indicate that differentiation in types of science courses is needed. A corollary to this is the introduction of science at the kindergarten level in order to permit time for differences in interest and ability to be developed and identified.

In an editorial in *Science*[1] the issue is clearly stated:

"If we consider the issue of the proper curriculum not as one of science versus the humanities, but as one of fundamentals versus applications, of gaining understanding versus memorizing rules, then we are presented with a happy paradox. In the present efforts at redesigning high-school science and mathematics programs, the more a course is revised to meet the Soviet scientific and technological challenge, the more it becomes a course appropriate to a liberal arts education."

The Physical Science Study at M.I.T. is placing more emphasis on developing concepts of wave motion and atomic particles and plays down attention to how a refrigerator works.

In summary, research contributes to the growth of new issues or, as we have facetiously stated it, "menaces." This in turn requires a further broadening and depth of investigations. A systematic research approach would contribute to the enlightenment of the professional and lay groups concerned.

D. What New Approaches Should Be Explored?

Research in science education can be improved by adapting the techniques and strategies that have been successfully used in other

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[1] "Scholars in Spite of Ourselves," *Science*, Volume 130, Number 3389, December 11, 1959, page 1627.

disciplines. For example, the "team approach," used in engineering and psychological research is worth exploring. A teacher, psychologist, social worker, and curriculum expert can investigate more effectively by contributing their talents where they are most needed.

The dynamics of group relationships should be explored as they relate to teacher-pupil and pupil-pupil relationships. Several studies of this type are described in cooperative Research Projects.[2]

What is the role of motivation in learning science? How can pupils be influenced toward greater interest, effort, and achievement? What are the status drives that motivate teachers to greater efforts?

What is creative thinking in science? Can it be stimulated and developed in pupils? How can this best be accomplished?

The above are by no means a complete summary of new approaches. Science education research can gain much by exploring the techniques of other disciplines.

E. From Whence Shall Research Leadership Come in Science Education?

Year after year we have heard that our research is incomplete in coverage, unplanned, unpatterned, and we might say, unsung. This criticism can be made in any area where there is no research leadership. This is a criticism of a system, not of individuals who have worked so generously and unselfishly.

What can be done to improve this situation? If we attempt to answer the following questions the solution may suggest itself.

1. What research is of greatest worth?
2. Who is best qualified to answer the above question?
3. What criteria or guiding principles can be used in determining the answer?

Our science education organizations should agree on a general pattern of research. They should agree upon long-range plans. There should be joint consultation regarding procedures and standards. If this is not done our groups may lose the initiative and even the decision-making role to the financial backers of research, the foundations, funds, and philanthropies. Though their intentions are most commendable there is a tendency for them to work in neat and manageable channels and to by-pass the novel, the speculative, the catalytic, the fermenting kind of study.

This is a need for all of the research groups mentioned earlier in section A. Each has an important contribution to make. It is not suggested that a boss be chosen to dictate but that the groups join in cooperative planning, agree on a policy, and work systematically. This is the secret weapon of America's greatness. Sputniks, missiles, and space stations disintegrate before it.

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[2] U. S. Office of Education, Dep't of Health, Education, and Welfare, *Cooperative Research Projects, Fiscal 1958*, Bulletin 1959, No. 8, pps. 32–44.

Review of Recent Research in College Level Science Education

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Let us turn first to the nine issues of the *American Journal of Physics* which appeared in 1959. This journal serves the 3500 or so members of the American Association of Physics Teachers and seems to be the logical outlet for research in the teaching of college level physics.

There were approximately 100 major and 50 minor articles. About 70% of the major and 50% of the minor articles were devoted to the elucidation of straight subject matter. Of the major articles devoted to teaching, such titles appear as "Evaluation of High School Physics Courses by College Students," "Graduate Examinations in Physics," "Summer Physics Program for Talented High School Students," "Physics for the First Grade," "Baccalaureate Origins of Ph.D. Physicists," and "Preparation of High School Teachers of Science."

This brief survey of the *American Journal of Physics* for 1959 produces two observations. First, authors seem to be much more willing "to take pen in hand" to describe their interpretation of the subject matter of physics than to discuss investigations of their successes or failures in teaching this subject matter. Second, the higher levels of the science teaching profession seem to be more concerned with the pedagogical problems of the lower grades than of their own undergraduate or graduate instruction.

Turning to the first 11 1959 issues of the *Journal of Chemical Education*, we find about the same distribution of emphasis in the major articles. More of the minor articles (60%), however, carry overt educational implications. Examples of pedagogically oriented titles are "A New Course in Synthetic Inorganic Chemistry," "Models for Demonstrating Electronegativity and 'Partial Charge,' " "A Meaningful Inorganic Chemistry Course," and "The Role of Kinetics in Teaching Inorganic Chemistry."

Again, this brief review of the *Journal of Chemical Education* for 1959 produces two observations. First, there seems to be a greater tendency to explore course design and content in chemistry than in physics and the other sciences. Second, there is a very active effort to create effective lecture demonstrations and laboratory exercises in chemistry.

No single publication available to this author provides an overview of the writing done during 1959 by college level life and earth science instructors.

Turning now to the general array of studies reported during late 1958 and 1959, we find titles which fall into several categories. These are (1) adaptations of course design and content, (2) characteristics of students prior to, during, or following college level instruction in science, (3) clarification or "standardization" of subject matter, (4) effectiveness of one classroom or laboratory procedure or teaching aid in comparison with another, and (5) evaluation techniques. A few examples of each category will now be quite briefly reviewed.

Harold Laster describes a modified version of the "free laboratory" in introductory physics which retains the orthodox characteristic of scheduling a new experiment every week but features two "long reports" in which each student is encouraged to swing out on an investigation of his own.

Ray Hefferlin developed an extension of Eric Rogers' "block-and-gap" approach by developing specific blocks and emphasizing how they can be "plugged into" various culminating subjects.

Miss Handler explored effects of overtly tying her teaching of biology to community resources. Students enjoyed her efforts but preferred straight lecturing when factual information was main aim.

Rufus M. Helms provides a good example of how to go about developing appropriate lab exercises for a prescribed block of subject matter. His approach clarifies principles, establishes current state of affairs, and priority of needs, design of equipment and/or procedure, and determines effectiveness in use. His approach yields not only new equipment but also improved instruction through self-inspection and criticism.

Gerald Holton in response to a commission from the AAPT Conference on the quality and effectiveness of introductory physics courses developed a syllabus addressed to non-physics majors with the material drawn from the history and philosophy of science and organized around "the seven basic principles and concepts" advocated by the AAPT conference.

Edythe M. Kershaw developed a list of duties and responsibilities of medical technologists to serve as a guide for the evaluation of medical technology curricula.

Paul H. Carnell examined 20 independent study programs for 1st year chemistry students. He decided that these programs serve the needs of gifted students and provide motivation for study of science as a career.

We will now turn to studies dealing with the characteristics of students.

R. C. Brasted found his first year chemistry students at the

University of Minnesota four times more likely to receive A's or B's if they had high school chemistry.

Irene Hollenbeck found that 66% of the Oregon College freshmen queried in her study had out-door science experiences.

Clifford B. Knight, Jr. questioned 792 biology students and found that 644 had some science in high school and found that 21.5% retained a general idea of "the steps," 33% a vague notion of the use of the method, and 20.8% had no concept of the method though they remembered they had heard about it in high school.

Frank B. Jex found for 48 of his 84 high school chemistry students that their overall high school grade record was a better predictor of college chemistry grades than IQ or Anderson Test scores.

Irvin J. Lehmann and Clarence H. Nelson characterized honors section students at a state university as being from a variety of backgrounds, enrolled in nearly all colleges although many are in engineering and physical science, the majority coming from upper and middle class homes, hoping to attend graduate school, were in upper third of a public high school graduating class, were from white-collar homes, had high ACE scores and received A and B grades. But are only slightly or moderately stimulated by their fellow honors students.

In a follow-up study, it was found that students liked being in honors label, instructors graded more severely, many failed to keep up, will accept extra work but not at the expense of quality, prefer labs to lectures, in fact, almost any instructional format was preferred over lectures.

George G. Mallinson and Conway C. Sams, using the Minnesota State Board Examinations in biology and chemistry, found that 506 male college freshmen differed only slightly from 341 females on biology scores, the men performed better in chemistry, and both sexes did better in biology than in chemistry.

Milo O. Stucky and Kenneth E. Anderson found that grade-point averages are better than placement tests in predicting how long a student will persist in college. Students with higher academic aptitudes stay longer, in general.

N. W. Hovey and A. Krohn found that the Iowa Chemistry Aptitude Test and the Toledo Chemistry Achievement Test were better than the Ohio State Psychological Examination and the Iowa State Psychological Examination in predicting success in college chemistry.

Adell Thompson found that 2100 students entering Kansas State Teachers College at Pittsburgh, 60.2%, 74.6%, 34.6% and 21.5% showed credits in biology, general science, chemistry, and physics.

Robert G. Brasted studying 1100 college students at the University of Minnesota decided that students from small high schools perform as well (or better) in chemistry than those from the large high schools, and students from parochial schools perform better than those from public schools.

Haym Kruglak polled 180 physics students at Western Michigan University and found (1) 80% had high school physics, (2) 50% thought the high school course was good to excellent in preparing them for college physics, (3) 50% had lab never to occasionally, (4) 75% had regular or frequent class demonstrations, (5) independence between extreme grades in general college physics and student ratings of their high school physics teacher, etc.

Samuel Strauss set out to determine if, in the opinion of experts, there is such a quality as "research ability." He concluded that there is and that it consists of such components as: drive or perseverance, intellectual ability, strong interests, curiosity, and hard work.

Only two examples will be cited from the category of subject matter clarification.

Rufus M. Helms sought letter-symbols for algebraic processes as practiced in current physics teaching that would be consistent, nonambiguous, and amenable to the typewriter.

Fannie W. Suffel concluded that the best of science fiction can be stimulating, encourages imagination, speculation, and frontier thinking; and is a valid literature for an age of science.

The following studies illustrate the category of comparison of teaching procedures and aids.

Hoping to see whether specialists can select the best laboratory exercises for general education physical science students, David A. Hilton concluded that a physics lab program is of little or no value in assisting students in understanding science principles. He still hopes to retrieve the laboratory by finding better exercises or something they can accomplish.

Joseph D. Novak used labeled photomicrographs in teaching college general botany and found they simplified instruction, increased student enthusiasm, but yielded no superior learning for sure.

John Breukelman, Ted F. Andrews, and Joseph D. Novak found that one lecturer supported by extensive teaching aids and a 3-hour per week class contact schedule could accomplish as much mastery of factual information in a lecture group up to 365 as was accomplished when the students were in small lab-lecture sections.

Joseph D. Novak found greater variability but the same degree of achievement in a botany course with and without independent project work.

H. W. Frings found no differences, except interest, in the achievement of general zoology students using (1) lab manuals, (2) unlabeled drawings, and (3) mimeographed experiments and questions without preserved materials.

George Alterman found the inductive method more effective than the deductive *only* for students with low preliminary background in physics. With the exception of critical thinking ability (Watson-Glaser Critical Thinking Appraisal) the various abilities in a college physics course are significantly correlated.

One study dealing with evaluation will be cited.

M. W. P. Strandberg and B. V. Godhale surveyed graduate examination procedures in the United States and found general dissatisfaction with the graduate examination structure. Problems seem to involve provincialism, penalizing potential, allowing probable failures to build up too great an equity in a degree they will never obtain, selection of really important material, and duplicating past examinations. Appendix provides sample questions which show scope of examinations.

Dr. Branson, who follows me, may want to discuss other implications of college level research but I hope he touches on the following questions.

Keeping in mind the number of people who are engaged primarily in college level science teaching, is an adequate number engaged in the study of the instructional process? Should this kind of research be considered to be as important as "pure" or "applied" research?

Why are college and university instructors currently more visibly concerned with the efficiency of instruction at the elementary or high school than at the undergraduate or graduate level? Is there a comparable array of problems at each level? For example, is the turning by young people to or away from science a problem only at the high school level?

Why are so many of the studies which attempt to compare the efficiency of one with another teaching procedure so likely to report "no significant differences"? Does this suggest that investigators are not tangling with the factors which really determine the efficiency of the teaching-learning process?

Implications of the Findings of Recent Research in College Level Science Education—1959

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Last year's delineation of the implications of recent research in college level science education emphasized two areas: the science student, and defining and stimulating creativity. Five other areas were mentioned only cursorily. It seems appropriate at this time, then, to attempt a more ambitious essay: the implications in all categories. I shall consider implication to mean "something implied that gives ground for an inference." Thus my position is that the existence of a study forces the inference that the results may be of value to some teacher, administrator, or student in conducting, modifying, eliminating, initiating, or arguing for an experiment, course, or program. It would be an unfortunate extrapolation of this statement to interpret it to mean that all studies are of equal worth or that all studies published in 1959 will be alluded to in this analysis. The first is patently not so and the second presupposes a dedication to bibliographic pursuits that the author does not have. Rather this report will present examples of each type of study, mentioning salient points in those the author has read either in total or, as in the case of the theses, in abstracts. One must admit the possibility that some excellent studies have been overlooked or are buried in some obscure or foreign language journal. Certainly all of us would like to know more about the developments in science education in at least one foreign country since the dramatic happening of October 4, 1957.[1]

The implications will be considered in six categories. This year again the studies appeared primarily in the periodicals, *The American Journal of Physics*, *The Journal of Chemical Education*, *The Science Teacher*, *Science Education*, SCHOOL SCIENCE AND MATHEMATICS, *The American Biology Teacher*, and, of course, *Dissertation Abstracts*. This report is based upon theses, articles, books, and 17 additional abstracts supplied by Dr. John Woodburn. No attempt has been made to adhere rigidly to any prescription that the research be done

[1] The *New York Times* Education Page, page E7, December 20, 1959, reported on an article by A. I. Yantsov, assistant director of the Institute of Teaching Methods at the Soviet Academy of Pedagogical Science, with the title "The Consequences of Contemporary Advances in Scientific knowledge on Secondary School Science Teaching." The most radical changes will be in physics (which will include the physical principles of automation and the peaceful uses of atomic energy), astronomy (will include an explanation of the significance of man-made satellites for the investigation of the earth as a celestial body), and biology (with special stress on the agronomic principles of agriculture).

Fred M. Hechinger who conducts the column containing the report concluded with some perceptive remarks on our systems, e.g., "American experts at present are replanning the science and mathematics curriculum, too. A convincing case can be made for a thoughtful, long-range, and thorough study before the actual changes are introduced. But this is the only legitimate excuse for delay—and there is no valid excuse for wasted time."

exclusively on the college level. Some studies, e.g., Conant's book, which have assuredly great significance for the college program are sometimes alluded to.

I. *Improved or Novel Methods of Presenting Topics—New Ideas, New Experiments, or New Materials* (6 references):

All of the periodicals referred to ahead except *Science Education* will carry several articles of this type in practically every issue. Typical studies related to community resources, new plug-in type physics course, new experiment in teaching alternating currents, new ways of presenting difficult concepts. An especially live topic in physics is the baffling clock paradox in relativity which was discussed in several recent articles directed to the teacher.

II. *New or Improved Courses or Program* (32 references):

Stromnes treated the general theory of curriculum construction in careful, philosophical terms. Specific programs, however, were the major examples in this category. Arons, for example, discussed the intellectually demanding freshman calculus-physics at Amherst College. While Kice, Brescia, and others argued for or examined instruction in certain phases of chemistry, (inorganic, polymer, qualitative analysis) in the college. Smith, Dermer, and Moore pointed out that they are able with students of above average ability to cover two semesters of work in one semester with no increase in class time, thus pointing a way to speed the training of chemists.

Inasmuch as "honors programs" are fashionable now, Codd's survey is especially welcome. He reported on 707 of 839 institutions queried revealing that 195 (27.6%) had some form of honors work while 512 (72.4%) had no form. In his opinion an honors program had two salutary effects: increase of students' interest in academic matters and an increase of the teachers' interest in teaching.

The conclusion of Hilton in selecting laboratory experiments and the value of such experiments in Physical Science may serve to arm our enemies, ". . . it is doubtful that any method for selecting experiments for Physical Science Laboratory could be identified as being better than any other method. The experimental evidence seems to support the conclusion that a Physical Science Laboratory program is of little or no value in assisting students in understanding science principles and that student opinion concerning the value of laboratory is of questionable value."

Another study with a pessimistic component was that of Bailey on teaching physics by television on the college level. Although he stated that instruction by television can be just as effective as regular classroom instruction, he admitted that 13 of the 21 students in the

experiment disliked the course. Sixteen would prefer a conventional course, but 12 preferred the television course to a large class of several sections.

In passing from this new instructional technique to a consideration of the content of the college program under the impact of changes in the scholarly world, we find Heumann and Bernays emphasized the needs in language proficiency beyond the usually required languages for chemists by their statistics on the survey of recent articles in *Chemical Abstracts:*

Language	*Number of Articles*	*Percentage of Total*
English	4823	50.49
Russian	1605	16.80
German	928	9.72
Japanese	583	6.10
French	524	5.48

The colleges might better meet increased responsibilities in language instruction, for example, if some of the college functions and responsibilities could be assumed by other agencies, notably the two-year or longer technical institutes. Phallen had much to say of interest on the technical institute movement and Pease discussed the success of the technical institute graduate.

On existing programs which are affecting the collegiate education of teachers of physics, Finlay, Ferris, and others had a well-balanced interim report on the Physical Science Study Committee. There has been, on the other hand, very little response to Vitrogan's excellent little book which should also affect the teaching of physics and the training of physics teachers.

With respect to secondary school teachers, Powers underscored the fact that the liberal arts college is the prime supplier of teachers in the physical sciences:

> (Sampling of 200 responses) . . . Two-thirds (131 cases) had done all of their baccalaureate work in a liberal arts college; more than one-fourth of the remainder (56 cases) had done part of their work in a liberal arts college. One in five (15 cases) were graduates of a normal school or teachers college.

He stated further along,

> What is needed, too, is provision in the curriculum of teacher education for prospective teachers to experience and gain practice in activities similar to those in which their high students will engage.

This final statement is a most appropriate introduction to what in my opinion may well be the most pervasive report of the year in its influence on the college program: The Purchase Guide of the Council of Chief State School Officers. This qualifies as a research report, for

a committee conducted a most careful study of laboratory instruction and recommended equipment in biology, chemistry, and general science under three headings: basic, standard, and advanced. Any secondary school offering a course in biology, for example, must have the basic equipment; it should have the basic and standard equipment. Secondary schools offering more than one year of these sciences or those wishing to be well-equipped should add the advanced items. The implication is clear that the teacher should have "experience and gain practice in activities similar" to those suggested by these lists. My guess is that the vast majority of our colleges do not send young people into teaching with these experiences and activities. Too few colleges have this equipment themselves! This Guide may be a persuasive ally for many a beleaguered science teacher to convince a harassed president that the teacher really needs the equipment he has been requesting for his elemental program.

The several excellent studies of experimental programs in education, The White Physics Films, "Continental Classroom," Advanced Placement, and others had must to suggest to the college with respect to procedures, design, and the evaluation of educational outcomes. The articles by Anderson and Montgomery, Lacey, Fitzpatrick, Gustad, Schenberg, and Valley were especially suggestive. Barnard reminded the science teachers, since too many of us behave as though we seek the one best method, that this search is for a chimera.

On the college science courses for non-science majors, Morrow supported his conclusion that "The science courses, as generally offered, are not adapted to the need and interest of the non-science students." This strong statement should send more of our colleges to study the suggestions of Myers and Crall on the biology curriculum, for example, or the report of Nelson who presented the taxonomy of educational objectives under two headings, cognative domain and intellectual abilities and skills. Moreover, Read, too, argued for "action research" in establishing courses.

III. *Studies of Texts and Suggestions for Texts or Syllabi* (4 references):

The number of studies in this area seems to be in sharp decline from last year. Fribourgh presented 50 recommended principles and generalizations for an introductory biology course in the junior college and incorporated them in a course of study. Dr. John Woodburn referred to an earlier study by Holton of a one-year college course in physical science which is organized around seven basic principles and concepts advocated by a conference of the American

Association of Physics Teachers. We hear a great deal about the "needs of students in this space age" and Wyatt advocated a course of study based upon agreed-upon-needs. Hatcher conducted an interesting experiment testing four different methods of conducting a general education science course:

1. Individual-consultation (maximum student participation).
2. Group discussion.
3. Class recitation (minimum student participation).

He reported about equal results for each method on four criteria.

IV. *Testing and Evaluating* (24 references):

The number of good studies in this area is too large for individual annotations. It seems appropriate to call attention to a few which may be labeled invitations to proceed cautiously in instituting new programs. The first is Abramson's report on the effect of ability grouping in high school on achievement in college which states that "no superiority of preparation can be claimed for either the special high school or the honor class program, as compared to heterogenous grouping within the comprehensive high school. Achievement of students was associated with intelligence level rather than the particular high school." The small class is not necessarily superior as most teachers assume, for Breukelman, Andrews, and Novak concluded

> "No significant differences in student achievement were found when mean scores were compared for lecture and laboratory methods with smaller classes, and lecture method only with one large section."

The carry-over in problem solving ability is often assumed but Alterman revealed

> "The ability to solve formula or mathematical-type problems in physics is significantly but not highly related with the ability to apply principles to new situations. Critical thinking ability (Watson-Glaser Critical Thinking Appraisal) does not significantly affect the ability to solve formula or mathematical type problems in physics."

Scientific method has been talked about so much that the teachers leaving college might be expected to carry it into their high school classes. But Knight found that of 792 college biology students with high school science credit, 25% had never heard of the scientific method in any high school course and that 20.8% had heard but had no concept of the method.

Lass' study of predictors for success in college science courses is an

example of a positive study, for he reported that success in college science courses correlated as follows:

General high school average	$r=0.59$
Chemistry test scores	$r=0.44$
Intelligence quotients	$r=0.31$

In a study of similar structure, Slotkin reported on the success of New York City technical and academic high school graduates in engineering schools. He found that the technical graduates were significantly superior on every criterion employed (college grade point average and percentage working at supervisory levels).

The evaluation of high school courses by college students is on the surface a most engaging procedure. Kruglak made a characteristically careful study for the high school physics course. Kruglak joined with Wall to publish a set of valuable laboratory performance tests for general physics under the support of the National Science Foundation.

Strandberg continued his analysis of examination procedures and philosophy. He had stated last year that

"1. The design and evaluation of examinations, as popularly applied, is nonquantitative.
2. The average student is inadequately prepared for understanding the learning process."

He proposed three steps which may aid in resolving these difficulties, the concept of logical steps, the concept of avenues of approach, and the concept of the nature of examinations. This year Strandberg collaborated with Goschale to consider graduate examinations in physics. One valuable by-product of this study is to reveal the wholly inadequate analytical or problem-solving emphasis in many of our colleges in comparison to what is expected at the strongest graduate schools.

V. *Characteristics of Science Students and Teachers* (33 references):

In selecting among these studies, the author has singled out a few with the broadest possible relevance. Hence the question of who interested students in science is rightly first. Welch reported that in order the following persons interested scientists in science: 1. Teacher 2. Self interest 3. Father 4. Adult friend 5. Relative 6. Young friend 7. Mother.

The characteristics of state systems should also have broad interest. For the Iowa high schools, Voss tabulated that

50% of the class assignments were to a single text.
65% of the teachers used community resources.
47% of the schools had science clubs.
40% of the teachers had four or more class preparations.

Few teachers had graduate preparation in science.
The average salary in 1957–1958 was $4455.75.

Garrett listed employment data on 1153 white college graduates certified to teach science in the Louisiana high schools from 1947–1956:

1/5 continued since graduation in teaching;
1/10 have taught intermittently but are teaching in 1956–1957;
1/5 entered teaching but left. Some in school-related employment; and nearly
1/2 never entered public school teaching at all!

Some facts for Ohio were reviewed by Davis, who reported that for the State as a whole one teacher in fourteen either had no science credit at all or none in his major area of teaching and an additional $\frac{1}{4}$ offered science preparation in only one area of science; $\frac{1}{3}$ of general science teachers had no physical science in college; almost no one had studied earth science; $\frac{1}{2}$ of the teachers did extra contractual work for pay during the school year and $\frac{1}{5}$ put in more than 11 hours per week in such work; most were textbook teachers; and "not more than $\frac{1}{2}$ of the teachers had any very deep grasp or insight into any philosophy of science teaching."

Colleges with National Science Foundation Research Training or Participation Programs for high school students will find interesting ideas and implications in the article by Bratherde and Johnston reporting their pleasant experience with using high school students as research assistants in working on the cyanoethylation of phenol and in their X-ray laboratory in the study of phase modifications of crystals.

In order for the high school teacher to understand students working in such research, it is essential that his training in modern physics and organic chemistry be fresh. Novak and Brooks reported obliquely on this idea in their study on what 196 Kansas science teachers thought their training should be in college courses to teach general science, chemistry, physics, or biology in the high school. Interestingly while 81% of the teachers thought organic chemistry essential to teach chemistry, only 54% thought a course in modern physics essential. The authors offered as a base for a college program those courses which 50% of the high school teachers regarded as "essential." Their criterion might be unfortunate even for the general science teacher who would study then only physics (90% essential), biology (80% essential), and chemistry (85% essential), leaving out geology (43% essential), and astronomy (38% essential).

VI. *Defining and Stimulating Creativity and Intellectual Growth*

Quality has become the shibboleth of the college program. Whatever ills are plaguing a school it must insist that it is maintaining a

high level of academic standards. The recommendations in the deservedly significant Conant report imply that the teacher of science must be a person of truly outstanding training and understanding. Rickover's book—which deserves to be read more and damned less—paid realistic attention to the central role of the teacher with full realization that a quality educational program revolves about an able group of teachers, possessing intellectual versatility and breadth but also satisfying depth.

A criterion as to how effective a college is in stimulating its students in depth is how many of the graduates go on the earn the Ph.D. Siebring alone and in collaboration with Schwahn proposed a new method of calculating a statistic for this criterion: the ratio of the number of the graduates who go on to take the Ph.D. in a given field in a given period to the number of bachelor's degree majors in that field during an equal period of time predated 4 or 5 years. They first applied this criterion to chemistry in 1954 and changed some of the usual names in the list of most effective colleges. More recently they have applied their procedure to physics using the Ph.D. degrees in 1952–1956 and the bachelor's degrees in 1947–1952. The southern schools, which have not shown up well under other criteria, do much better using this formula. Hampden-Sydney College led the list in physics with an 80, i.e., 80% of the students graduating with majors in physics in 1947–1952 went on to take Ph.D.'s in 1952–1956! It is obvious, however, that this ratio can be a very misleading parameter.

Although McGrath might object to the use of such Ph.D. productivity data in adjudging a liberal arts college, the measure featured prominently in a National Science Foundation sponsored conference at the College of Wooster in June, 1959 where data were produced showing that 341 undergraduate institutions when examined for the 20-year period 1936–1956 ranked

30 produced 30 or more students who went on to earn a Ph.D.
45 produced 15–29
100 produced 5–14
166 produced 4–0

Many produced none at all. Lewis reporting on 625 liberal arts colleges revealed that $\frac{1}{3}$ failed to provide undergraduate training for a single Ph.D. in 21 years; $\frac{1}{2}$ trained two or less; some 75 or 85 colleges were the most productive.

These studies read for this report represent planned pattern research of high quality. Although most of the studies may still be thought of as dealing with problems of simplicity with a very few variable, there was general recognition that the problems are abstractions from problems of disorganized complexity—to use Weaver's terms. It is true that one finds little of the Kurt Lewin approach. It is also true that the techniques now being developed in operations

research, game theory, and market analysis requiring the use of high speed computers to reduce the data, have not invaded this area although there is little doubt that more impressive and reliable studies especially of methods would result from employing these more elaborate research techniques.[2]

The most often mentioned concern of American institutions of higher learning is lack of funds. Here in science education we discern this factor, for to employ computers and research teams presupposes research funds of another order of magnitude than are normally available in this field.

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[2] We can see this point by considering a hypothetical example of the testing of these different methods of instruction (M_1, M_2, M_3) in three different classes (C_1, C_2, C_3) by three different teachers (T_1, T_2, T_3). A minimum requirement of randomization would be that each method be employed by each teacher with each class ($M_1C_1T_1$, $M_1C_2T_1$, $M_1C_3T_1$, etc.). This procedure would yield results for 27 tridads. Although with such a small number of samples, the results would not be considered as very reliable; yet even this design would be most difficult to achieve in science education where it seems to be needed.

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Summary of Reviews and Implications

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It has been our pleasure and privilege to hear reviews of nearly one hundred studies in science education which were completed or reported in the interval from July 1957 to July 1959. These studies were selected by use of certain criteria, including, of course, the availability of published reports or of the original to members of the reviewing committees whose chairmen have spoken to you this morning. Sixteen studies were included in elementary science education, 47 on the secondary level, and 29 on the college level, roughly 1 to 3 to 2.

Three papers this morning have provided analyses of the implications of these 92 researches to the teaching of science at the respective academic levels.

It seems most fitting now that these researches be reported and analyzed and criticized thoroughly. Science teachers and teaching scientists, of all people, must in these days long for and work for a science of science education as the most valid, or one of the few thoroughly valid bases for our professional efforts.

I shall not repeat the reports and implications, but shall summarize aspects of both. The large number and considerable variety of the studies present a double challenge. They highlight the magnitude and importance of our part in American education and they present in strong perspective the need for better communication among professional scholars and researchers in education.

Dr. Wheeler reviewed studies classified as Experimental, Analytic, and Synthetic. Dr. Evans classified the secondary level studies as related to developing teaching fields, to training science teachers, and to learning, interests, and attitudes. Dr. Woodburn's grouping included studies involved in course design and content, characteristics of students, clarification of content, comparison of methods, and evaluation. When taken as a total group, the studies can be classified variously. In one rough grouping, which no doubt does less than full justice to several studies, nine categories can be used. One study only dealt with the historical aspects on a comparative basis; one dealt with sequence of science subjects; two dealt with supervision; four resulted in printed source materials for teachers' use; seven were involved extensively with testing or other evaluation. (Of course others used tests.) Eight dealt with teacher education at length. Eighteen compared methods of instruction. Twenty-one constructed or modified curricula, and 26 measured or tabulated aspects of status.

Probably the largest group of the studies, in terms of academic relationship, consisted of doctoral studies, no doubt both Ed.D. and Ph.D. Masters theses are second in number, and non-degree, post doctoral, or otherwise independent studies are fewest. Probably degree requirements tend to have a fragmenting effect and to minimize research designed to recheck earlier research, a condition deplored by some.

A rough tabulation of the sources of data for a majority of the studies reported today indicates at least 45 researchers used questionnaires or interviews or both. At least 25 studies involved written examinations, and with them the ever-present question of validity, especially when the more subtle objectives are to be measured.

Fifteen or more of the studies were based to a considerable extent upon analyses and syntheses of material from publications—library

research—involving various professional writings but including several analyses of courses of study. Only three appear to have involved extensive use of direct observations of pupils, although three others used anecdotal records.

The three speakers who discussed implications, and the reviewers also in their several excellent closing remarks, have provided challenging suggestions and questions which I would summarize under two categories. First, they mentioned several and, I believe, implied other very specific implications of these particular studies to science education. The measurements of outcomes of classroom TV and of the uses of the several experimental methods of teaching can obviously be of service to any who are considering the use of such educational developments.

Dr. Reiner's testing indicates that educational TV is probably here to stay. But he reassures the personally fearful—apparently teachers also are here to stay.

The new courses and curricula and other publications can be adopted or modified for use by others, and the methods used in determining them can also be used by others. Probably the procedure of analyzing courses of study as a basis for planning a new one can be carried too far. A course of study based solely upon a survey of practice can have an elevating effect only on submarginal teaching. Its overall effect is apt to consist largely of leveling downward, not upward.

Each study reviewed this morning has valuable potential for use by those having similar problems or interests. Some may use the findings, some the method or modifications thereof.

In addition to the foregoing and other self-evident implications of the studies reviewed today, a second kind or group of implications received even more attention from the speakers of the morning. These are implications to science educators who conduct or advise research. They are based on a philosophy of science education and on the general state of research in science teaching as seen over a period of several years and including, but not limited to, the studies reviewed today.

From each level—elementary, secondary, college—one or both speakers have called for more fundamental, basic research. Research of this sort was never more needed, the 20th century being what it is, even though this year's "crop" of studies has evident quality. Our times have long since demanded but not received a generation blessed with true scientific literacy. More than literacy, we need creativity of increasingly high order, at least from those naturally endowed with the requisite potential. And we need on the part of the least among us a sound perspective concerning the "creations" of

science and technology. And this at a time, as Dr. Evans so aptly put it, when we can scarcely define good science teaching.

The criteria of learning are, I believe, recall and transfer. The first step, or an early step, in developing a true *science* of education in science is to learn to evaluate learning. The 37th yearbook of the NSSE dealt in Part II with the scientific movement in education, and the 45th. Part I, with the measurement of understanding. Now, these many years later we measure recall best, and most of our science teachers measure recall exclusively. Your speakers of the morning called for reliable and valid measurement of student growth toward *each* of the objectives of instruction in science.

The speakers of the morning stated specifically that we can be more scientific in our approaches to most of the following, and implied the same, I believe, regarding the others:

Why do we teach science?
What science shall we teach?
How shall we organize it for teaching?

How shall we teach it?—To the talented, of course, and also to nearly all the children in all the land, and for growth in all the objectives. Individual differences, like TV, taxes, and teachers, are here to stay. The members of a more literate public have more possibilities for differing from each other.

What facilities are needed for instruction?

How to relate the sciences to each other and to the rest of the curriculum?

How to evaluate the results of our efforts?

How to administer and supervise?

How to train teachers, both pre- and in-service?

How to achieve integration of content, of experience, and of personality?

These problems have relevance to a lesson, to a unit, to a year's work, and to a program for science in general education for grades K-14. This is current unfinished business, though the title and theme of the 31st yearbook. They (the problems) probably will not be solved in time for the reviews next December, 1960, but one can expect with confidence that progress will be made by then, and probably achieved or assisted by members of the organizations meeting here today.

Since the nature of learning was stressed by nearly all speakers as worthy of our best research efforts, it should be mentioned specifically in this summary. We need to know more about motivation and interest. Vannevar Bush wrote of the motivation of scientists as ris-

ing from many and varied sources—altruistic, religious, materialistic, the influence of another person, and more. Perhaps sources of motivation and interest of children can be identified and their effects measured.

One of the yearbooks, the 31st, contains perhaps an oversimplification to the effect that skill in scientific method, like other skills, can be achieved if the learner (a) understands how the skill functions, and (b) practices it. Classroom research, illustrated in one of the studies reviewed today, gives pupils experience in inquiry of a scientific nature. They can live it; they can act like scientists. Three of our speakers asked for more study of teaching of this kind. This may provide opportunity for further study of the function of group dynamics and of research team activity in learning science, also recommended by speakers of the morning. Such research may reveal whether science should be thought of as a way of living, and within what limits, and may clarify some of the relationship between science and the values basic to best human relations.

A final and important item in this summary is the recommendation coming independently from two of the speakers that a central guiding agency such as a Research Council be set up through the AAAS and the NARST and affiliated organizations. This could give some guidance and unity and coherence to the far flung individual efforts that can produce 92 selected studies in one period. And it might bring added resources in the form of foundation or other support for such projects as continuing post doctoral research, rechecking of individual research enterprises, and long range study of problems or clusters of problems of the nature of learning in science, its cultivation, and its evaluation.

Let's plan now so that we can give Dr. Evans a full scientific definition of good science teaching and also valid criteria for its evaluation. If we don't move forward in our research we may find the ball gone from our hands and carried in a direction chosen, perhaps, by a committee or an individual whose prestige may delay realization that a fresh look at science teaching is valid and constructive only so far as its objectives have breadth and pertinence, its understanding of youth and of learning is thorough and profound, and its evaluation measures reliably and with adequate precision what it purports to measure.

MOON HAS ATMOSPHERE OF COLD NEUTRAL HYDROGEN

The moon has an atmosphere of cold neutral hydrogen, the basic material of the universe, as well as a minute amount of argon, two U. S. scientists reported. Protons in the solar wind bombarding the moon's surface produce both the hydrogen and argon in the lunar atmosphere.

My Father, My Dog and Mathematics

Ben L. Swensen

Robert E. Lee High School, Baytown, Texas

A rose by any name would smell as sweet. It remains to be proven, however, that stated problems by any other name would be more palatable to many students of mathematics. Despite the many arguments offered to support the practicality of such problems, the student considers them at best a necessary evil. Rather than argue the point, let us consider the following:

> You know those terrible arithmetic problems about how many peaches some people buy, and so forth? Well, here's one we like, made up by a third grader who was asked to think up a problem similar to the ones in his book: "My father is forty-five years old. My dog is eight. If my dog was a human being, he would be fifty-six years old. How old would my father be if he was a dog? How old would my father plus my dog be if they were both human beings?"[1]

At first reading, this problem appears to be useful only for its humorous quality. It certainly has no practicality. On the other hand, a closer inspection by students[2] more advanced than the author of the problem led to the following solution:

1. Let us assume that the third-grader was aware of the apparent longer life of humans in comparison to dogs, and that his problem was an attempt to show the relationship between the life expectencies of the two species.
2. We are told that the boy's dog would be 56 if he were a human. Since he is actually only 8 "dog" years old, and since 56 divided by 8 is 7, then his age (in "dog" years) must have been multiplied by 7 to convert it to "human" years. Stated algebraically:

$$7D = H \qquad \text{(a) or,}$$

$$\frac{1}{7} = \frac{D}{H} \qquad \text{(b)}$$

   where D = "dog" years, and H = "human" years.
3. Using this relationship, we convert the father's age (in "human" years) to "dog" age in the following manner:

[1] Fadiman, Clifton (Editor), *Fantasia Mathematica*, N. Y., Simon and Shuster, (1958), p. 292. (Originally appeared in *Talk of the Town*, copyright 1957 by the New Yorker Magazine, Inc.)

[2] The writer acknowledges the several students in his classes at Robert E. Lee High School, Baytown, Texas, who solved the problem.

$$\frac{1}{7}=\frac{D}{H} \qquad \text{(b)}$$

$$D=\frac{H}{7} \qquad \text{(c) Solving for } D$$

$$D=\frac{45}{7}=6\ \frac{3}{7} \qquad \text{(d) Substitution, simplifying}$$

The father is then $6\frac{3}{7}$ "dog" years old.

4. The answer to the second part of the question is rather simple. The father is 45, the dog is said to be 56 (in "human" years). The sum of their ages is then 45+65, or 101 "human" years.

If any conclusions may be drawn from this, perhaps it is that while the teacher teaches stated problem, and the student solves them, they both experience a "dog's life," but it need not be one devoid of humor.

SCIENTISTS USE ORGANISMS TO WIPE OUT INSECT PESTS

The growing resistance of disease-bearing insects to many of the chemical insecticides is prompting greater use of biological insect control.

Biological, or natural, control is checking insect growth by use of such natural parasites or predators as viruses, bacteria, fungi, nematodes (worms), protozoa, or other larger organisms.

Natural control has had a limited use for some time. The Japanese beetle, for example, is now largely controlled by a white spore dusted on lawns, which causes milky spore disease in the beetles and results in their death.

The introduction of effective chemical insecticides, such as DDT, in the control of insects resulted in a general abandonment of interest in natural control. Increased insect resistance to insecticides, however, and the fact that large-scale use of some insecticides has also killed off many organisms that normally feed on insect pests, have renewed scientific interest in natural control as a supplemental means of insect eradication or as a replacement for chemical means.

SILICON ISOTOPE MAY DATE OCEANOGRAPHIC PHENOMENA

A radioactive isotope of silicon that shows promise as a means for dating oceanographic phenomena has been found in marine sponges in the Gulf of California.

Known as silicon-32, the isotope is produced by cosmic rays and has a half-life of roughly 710 years. It is believed to be found principally in the oceans, deposited there by rain.

Such isotopes as carbon-14, hydrogen-3, beryllium-10, and phosphorus-32, also produced by cosmic rays, have previously led, on the basis of their distribution and concentration in different areas of the earth, to many significant concepts in geochemistry and geophysics. It is hoped that silicon-32 will prove equally valuable.

Its use as a tracer could facilitate studies of mixing times between deep water and surface water. It could also be used to study ages of the polar ice caps, rates of accumulation of rapidly growing siliceous sediments, individual characteristics of water masses within oceans, and changes in cosmic ray intensity with time during the last few thousand years.

Locating the Decimal Point in Slide Rule Answers

Wendell F. Bennett

Head of the Science Department, Natick High School, Natick, Massachusetts

The slide rule has long been the mark of the engineer and the engineering student. Its use in college by the engineering student is most essential from a time-saving point of view. Even in many of our high schools the use of the slide rule is encouraged, or, in many cases, made mandatory especially by teachers of the physical sciences.

It is relatively easy for the teacher to teach, and for the student to learn, the use of the slide rule in multiplication, division, or combination multiplication and division problems. Too often, however, the student is unable to determine the correct answer from his slide rule answer—where he should locate his decimal point he has not the faintest idea. As a result of his uncertainty, the student all-too-frequently resorts to the traditional pencil and paper method of solving his problem, and the slide rule is immediately discarded and soon forgotten. The purpose of this article is to present a method of teaching decimal point location that is neither novel nor new, but that has proven effective in giving the student confidence in his slide rule answer, and in reducing the frequency of pencil and paper answers to problems in physics.

Considerable time is spent in teaching the student the basic slide rule manipulation necessary for multiplication and division, and in reading his answer from the slide rule. At this time no attempt is made to read any decimal point into the problem; all answers are read only as digits from the slide rule to make certain that the students are accurate in their settings, and in their readings. Once the student has mastered this phase of the use of the slide rule, the teaching of decimal point location is undertaken.

The first examples that are placed on the chalkboard are simple examples in multiplication and division. The answers to these examples are obtained on the slide rule (by the students) and are written on the board. The student is able to tell by inspection where his decimal point should be located in his slide rule answer. They are asked this question, and the decimal point is properly located. The following examples (1) and (2) illustrate this point:

(1) $8.059 \times 3.771 = 304.$ (2) $\dfrac{7.386}{8.022} = 918.$

In example (1) the student can readily see that the correct answer should be 30.4, while in example (2) the answer should be .918. The students are then asked to explain how they knew the decimal point

should be located as indicated in these two examples. After listening to their comments and explanations, I then place an example such as the following (3) on the board, and ask them where the decimal point should be in this example:

$$\frac{740.33}{.009026}=821. \tag{3}$$

Some students will have the correct decimal point location, but most of them will not. I raise this point with them to emphasize the point that the numerical answer from their slide rule means very little unless they are certain of the correct order of magnitude of their answer, and can thus locate their decimal point.

A review of the scientific notation, or numbers written to the base 10, and the laws of exponents is then made. The following series of examples is then placed on the board to show them how this knowledge may be applied to the use of the slide rule:

$$\frac{8000}{2000}=4; \quad \frac{8000}{2000}=\frac{8\times 10^3}{2\times 10^3}=4\times 10^0=4. \tag{4}$$

$$\frac{8000}{20}=\frac{8\times 10^3}{2\times 10^1}=4\times 10^2=400. \tag{5}$$

$$\frac{8000}{20{,}000}=\frac{8\times 10^3}{2\times 10^4}=4\times 10^{-1}=.4. \tag{6}$$

$$\frac{8107}{23{,}055}=352; \quad \frac{8107}{23{,}055}=\frac{8.107\times 10^3}{2.3055\times 10^4}=.352. \tag{7}$$

The above procedure seems like a great deal of work to most students, so before they have a chance to complain, I explain to them the mental survey method of getting their answer, based on the above procedure. I have them follow the following sequence:

(1) Treat both numerator and denominator as a whole number followed by the appropriate power of 10.
(2) Place the power of 10 to the left of both numerator and denominator.
(3) Divide the single digit numerator by the single digit denominator.
(4) Divide (subtract) the exponents.
(5) Locate the decimal point in the answer.

Examples, such as the following, are then placed on the board to verify the procedure outlined above:

(7) $$\frac{10^3}{10^4}\ \frac{8107.}{23055.}=352; \quad \frac{8}{2}=4; \quad \frac{10^3}{10^4}=10^{-1}.$$

The answer by mental survey is therefore 4×10^{-1}, or by slide rule it is 3.52×10^{-1}.

(8) $$\frac{10^2}{10^{-3}}\ \frac{740.33}{.009026}=821; \quad \frac{7}{9}=.8 \text{ (rounded off to one digit)} \frac{10^2}{10^{-3}}=10^5.$$

The answer by mental survey is therefore $.8\times10^5$, or $.821\times10^5$ by slide rule.

(9) $$\frac{10^{-1}}{10^1}\ \frac{.7892}{84.09}=936; \quad \frac{7}{8}=.9; \quad \frac{10^{-1}}{10^1}=10^{-2}.$$

The answer by mental survey is thus $.9\times10^{-2}$, or by slide rule $.936\times10^{-2}$.

After a few practice examples, many of the students are able to follow much of the above procedure mentally, and locate the decimal point in division examples with little difficulty.

A similar procedure is then followed for multiplication examples. Problems like the following (10) are given first:

(10) $500\times100\times7000\times.001=35$ (by slide rule or inspection).

The students rewrite the problem as follows:

(10) $$5\times10^2\cdot1\times10^2\cdot7\times10^3\cdot1\times10^{-3}=35\times10^4.$$

The answer is therefore 35×10^4, or 350,000.

The next series is more complex, but is done in similar manner.

(11) $509.2\times100.76\times7109.3\times.001596=582$ (by slide rule).

Rewriting this problem as indicated above, the student has:

(11) $$5.09\times10^2\cdot1.008\times10^2\cdot7.11\times10^3\cdot1.60\times10^{-3}=58.2\times10^4,$$

or 582,000.

But here again the student will not know where I obtained the 58.2. The slide rule gives him 582, while the powers of 10 give him 10^4. Using the mental survey method, I go thru the procedure to obtain the approximate product of each of the first digits orally as follows:

"5 times 1 is 5, times 7 is 35, times 2 (rounded off) is 70. My slide rule answer is 582, so I know that the answer should be 58.2. Multiplying (adding) the exponents for the powers of 10 I get 10^4, so my answer becomes 58.2×10^4 or 582,000. The fact that my mental survey answer is 70 rather than 58 or 59 is not significant; it does tell me,

however, that my answer must be 58.2 and not 5.82 or 582, or even some other possible answer."

Combination multiplication and division examples are then placed on the board. An example such as the following (12) illustrates the procedure that is followed:

$$(12) \qquad \frac{82.063}{.04062} \times \frac{952.66}{75.336} \times \frac{5.0593}{.8496} = 1521.$$

I rewrite the problem using the scientific notation, but disregarding all digits following the first whole number digit:

$$(12) \qquad \frac{8\times 10^{1} \cdot 9\times 10^{2} \cdot 5\times 10^{0}}{4\times 10^{-2} \cdot 7\times 10^{1} \cdot 8\times 10^{-1}} = 1521 \text{ (slide rule).}$$

8 times 9 is 72 (call it 70) times 5 is 350; the numerator is thus 350. The denominator is 4 times 7 is 28 (call it 30—or 25 would also be close enough) times 8 is 240. The fractional whole-number answer is therefore

$$\frac{350}{240} = 1.5$$

approximately. The answer for the power of 10 in the numerator is $+3$, for the denominator is -2; the fraction for the exponents is thus

$$\frac{+3}{-2} = +5.$$

The slide rule answer is consequently $1.5\times 10^{+5}$, or $1.521\times 10^{+5}$. In this particular case the mental survey answer and the slide rule answer were about the same, but it should be emphasized that such correspondence is not at all necessary. The mental survey process is desirable, however, to check the reasonableness of the slide rule answer; in case of any unreasonable difference, the student should check on his slide rule answer or his mental survey answer to see if any mistake had been made.

The final step in the instructional process for decimal point location, for combination examples, is to have students solve problems like (13) below, but with a minimum of pencil and paper work:

$$(13) \qquad \frac{139.78}{.9773} \times \frac{.05079}{124.9} \times \frac{1947.7}{66.709} \times \frac{.0881}{57.80} = 262;$$

$$= 2.62\times 10^{-3} \quad \frac{+1}{+3} \quad \frac{80}{240} = .3\times 10^{-2}.$$

The answer is, therefore, $.262\times 10^{-2}$, or, as indicated above (with one whole number digit before the decimal point) 2.62×10^{-3}.

Silvering of Glass

Ralph E. Dunbar

North Dakota State College, Fargo, North Dakota

In the silvering of glass articles and surfaces, distilled water should be used in making all solutions and in washing all surfaces. The cleaning of the surface of the glass to be silvered is of prime importance. A satisfactory surface cannot possibly be obtained if there is the slightest bit of grease on the glass. The surface of the glass can be advantageously cleaned by rubbing it with some fine moist ferric oxide (rouge). The rouge is then washed off but the hands must not touch the face of the glass. A small soft brush or tuft of cotton may be used in this operation.

One gram of stannous chloride and 1 ml. of concentrated hydrochloric acid is dissolved in 25 ml. of distilled water. This solution is then further diluted to 375 ml. with distilled water. The surface of the glass which is to be plated is now washed with this diluted solution of stanneous chloride, again avoiding any contact of the hands with the surface to be plated. The glass surface is then again thoroughly washed with distilled water.

Ten grams of silver nitrate is now dissolved in 10 ml. of concentrated ammonium hydroxide (sp. gr. .90). This solution is then diluted with the addition of 160 ml. of distilled water, thoroughly stirred and filtered. This solution may be preserved in a dark bottle for future use, and will be subsequently referred to as solution (A). Ten grams of potassium sodium tartrate (Rochell salt) is dissolved in 160 ml. of distilled water, thoroughly stirred and filtered. This solution will be subsequently referred to as solution (B). To mix for silvering, equal volumes of solutions (A) and (B) are used and twice the combined volume of (A) and (B) of distilled water is added. The glass to be silvered, which must have been previously cleaned, is now placed on a perfectly flat surface where dirt will not settle. The mixed solution is now poured upon the upper surface of the glass, capillary attraction holding the solution on the surface and up to the very edge of the glass. Flasks, beakers and similar containers may be filled with the silvering solution. The entire surface to be plated must be completely covered with the solution at all times. No heating is required. On standing for an hour or so, the silver will deposit on the glass producing the mirror. A second or third portion of the silvering solution may be used to increase the amount of the deposition. However, the surface must never be allowed to dry and should be completely covered by the silvering solution during the entire process. These mixed silvering solutions of this type or their residues, when allowed to stand for long periods, have been known to explode with considerable violence, due to the formation of silver nitride. Due caution should, therefore, be exercised at all times in disposing of residues.

In the mirror trade, after the silver is deposited on the glass, it is dried on a hot table and the back is first painted with pure orange shellac made from pure grain alcohol and then painted with a special mirror paint to protect the silvering.

Stopcock Grease

Ralph E. Dunbar

Ten parts of vaseline and 2 parts of white paraffin are melted together on an oil bath and then 1 part of pale crepe rubber, cut into small pieces, is added. The whole is heated (in a hood) and stirred until a smooth, homogeneous solution is obtained. When cool this preparation makes a satisfactory lubricant for glass stopcocks, desiccators, etc. The viscosity of the wax can be increased by the addition of a greater percentage of rubber or decreased by increasing the proportion of vaseline. Pure gum rubber tubing or stoppers may be substituted for the crepe rubber, when the latter is not available, without greatly decreasing the quality of the product.

PROBLEM DEPARTMENT

Conducted by Margaret F. Willerding

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note: Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2695, 2698, 2704, 2706. *C. W. Trigg, Los Angeles, Calif.*

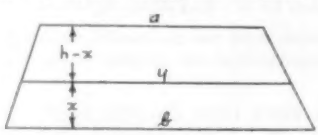
2701, 2702. *Leon Bankoff, Los Angeles, Calif.*

2701. *Anne Gift, Oradell, N. J.*

2707. *Proposed by Merrill Barnebey, Tougaloo, Miss.*

Sometime in the early 1920's a party of surveyors in California was faced with the problem of dividing a trapezoidal piece of land into two equal portions by means of a line parallel to the two parallel sides. Solve this problem for the surveyors.

Solution by C. W. Trigg, Los Angeles, Calif.



Let the bases of the trapezoid be a and b, the dividing parallel be y, the distance between the bases be h and the distance between b and y be x.

Then equating areas:

$$\tfrac{1}{2}(h-x)(a+y)=\tfrac{1}{2}x(b+y),$$

so

$$x=h(a+y)/(a+b+2y).$$

Also,

$$\tfrac{1}{2}(h-x)(a+y)+\tfrac{1}{2}x(b+y)=\tfrac{1}{2}h(a+b),$$

so

$$x=h(b-y)/(b-a).$$

Equating the two values of x, and solving:

$$y=\sqrt{(b^2+a^2)/2}, \quad \text{so } x=h(b-\sqrt{(b^2+a^2)/2})/(b-a).$$

Solutions were also offered by Leon Bankoff, Los Angeles, Calif.; Charles H. Butler, Kalamazoo, Mich.; Herta Freitag, Roanoke, Va.; O. F. McCrary, Raleigh, N. C.; Fred Miller, Elkins, W. Va.; and Dale Woods, Kirksville, Mo.

2708. *Proposed by Cecil B. Read, of Wichita, Kans.*

The number $abcd$ has the property that $(ab+cd)^2=abcd$. Find the number.

Solution by the proposer:

Since

$$(ab+cd)^2=abcd$$
$$(ab+cd)(ab+cd-1)=ab00-ab$$
$$=ab(99).$$

Hence of $abcd=n$

$$n(n-1) \text{ is divisible by } 99$$

and since n^2 is a four digit number

$$32\leq n\leq 99.$$

In this range the only cases in which $n(n-1)$ is divisible by 99 are 45, 55, and 99.

Hence $n=2025$, 3025, 9801 and the special case 0001.

Solutions were also offered by Walter R. Talbot, Jefferson City, Mo.; C. W. Trigg, Los Angeles, Calif.; and Dale Woods, Kirksville, Mo.

2709. *Proposed by Leo Moser, University of Alberta.*

A club consisting of ten members decided to form a number of committees of various sizes. No member was to belong to more than one committee. After the number and size of the committees had been tentatively set, one member suggested that each committee should be increased in size by one. He claimed that this would increase the number of ways of choosing committees. Another member countered with the statement that the number of ways of choosing the committees would be decreased. A third said that both were wrong. He was right. What was the size of the committees as originally proposed?

Solution by W. R. Talbot, Jefferson City, Mo.

For k committees there must be at least k members not on committees; so there are at most 5 committees of one member each. There are not 5 committees because

$$C(10, 1)C(9, 1)C(8, 1)C(7, 1)C(6, 1)\neq C(10, 2)C(9, 2)C(8, 2)C(7, 2)C(6, 2).$$

There must be more than one committee because $C(10, m)\neq C(10, m+1)$.

Assume there are 4 committees with a, b, c, d members each where $n=a+b+c+d\leq 6$. The equality of the problem gives

$$C(10, a)C(10-a, b)C(10-a-b, c)C(10-a-b-c, d)$$
$$=C(10, a+1)C(9-a, b+1)C(8-a-b, c+1)C(7-a-b-c, d+1).$$

From the facts that

$$C(s, r)=\frac{s!}{r!(s-r)!} \quad \text{and} \quad (r+1)!=r!(r+1),$$

we cancel the equality down to

$$1/(10-n)!=1/(6-n)!(a+1)(b+1)(c+1)(d+1).$$

We may cancel the factorials further and rewrite the equality as

$$(a+1)(b+1)(c+1)(d+1)=(10-n)(9-n)(8-n)(7-n).$$

If $n=6$, the right member is $4\cdot 3\cdot 2\cdot 1$. The left member could have $a, b, c, d=3, 2, 1, 0$. These are the only partitions of 6 into 4 parts (including 0) which when increased by one have a product of 24. An acceptable arrangement, then, is 3 committees with 3, 2, and 1 members. For $n<6$, the right member gets larger whereas the condition $n=a+b+c+d$ makes the left member smaller, and no other possible solutions are obtained. By similar means we find there could be 2 committees with 5 and 1 members.

2710. *Proposed by C. W. Trigg, Los Angeles, Calif.*

Through the foot of the altitude, CD, to the hypotenuse of the right triangle ABC a line v drawn parallel to BC meeting AC in E. Find the area of ABC in terms of EC and angle A.

Solution by Leon Bankoff, Los Angeles, Calif.

From the relation

$$CE\cdot CA=CD^2$$

we obtain

$$EC/AC=CD^2/AC^2=\sin^2 A,$$

or

$$AC=CE\csc^2 A.$$

But

$$AB=AC\sec A.$$

Hence

$$AB=CE\csc^2 A\sec A.$$

Now

$$CD=CE\csc A.$$

Hence area of triangle

$$ABC=(CE\csc^2 A\sec A)(CE\csc A)/2=(CE^2\csc^3 A\sec A)/2.$$

Solution II

$$AB=CB\csc A=CD\sec A\csc A=EC\csc^2 A\sec A$$
$$CD=CE\csc A.$$

Area of triangle

$$ABC=AB\cdot CD/2=(CE^2\csc^3 A\sec A)/2.$$

Solutions were also offered by Charles H. Butler, Kalamazoo, Mich.; Herta Freitag, Roanoke, Va.; Ronald Klipsch, Indianapolis, Ind.; W. R. Talbot, Jefferson City, Mo.; Dale Woods, Kirksville, Mo.; and the proposer.

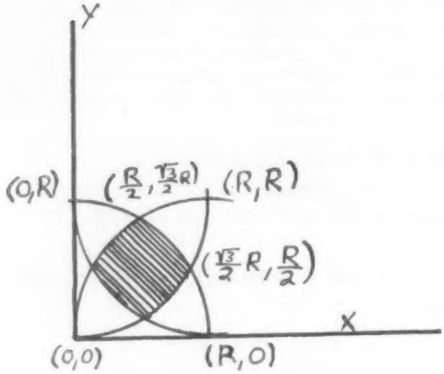
2711. *Proposed by John Nayler, Alberta, Canada.*

The centers of four equal circles of radius R are at the corners of a square of side R. Find the area common to all four circles.

Solution by Donald R. Byrkit, West Chicago, Ill.

The four circles can be represented by the following equations:

$$x^2+y^2=R$$
$$(x-R)^2+y^2=R^2$$
$$(x-R)^2+(y-R)^2=R^2$$
$$x^2+(y-R)^2=R^2.$$



Their intersections are indicated on the accompanying diagram. The common area (shaded) can be considered as twice the area between $x^2+y^2=R^2$ and $x^2+(y-R)^2=R^2$ as x ranges from

$$\frac{R}{2} \text{ to } \frac{\sqrt{3}R}{2}.$$

The functions of x in the range indicated are $y=\sqrt{(R^2-x^2)}$ and $y=R-\sqrt{(R^2-x^2)}$. The negative square root of the right side of the equation is taken since $y<R$ in the indicated range.

The area of the shaded area then is as follows:

$$A=2\int_{R/2}^{\sqrt{3}/2R}(2\sqrt{R^2-x^2}-R)dx.$$
$$A=(\pi/3+1-\sqrt{3})R^2\approx .3151R^2.$$

Solutions were also offered by Leon Bankoff, Los Angeles, Calif.; Charles H. Butler, Kalamazoo, Mich.; Thomas Curry, Oyster Bay, N. Y.; Fred A. Miller, Elkins, W. Va.; W. R. Talbot, Jefferson City, Mo.; C. W. Trigg, Los Angeles, Calif.; and Dale Woods, Kirksville, Mo.

2712. *Proposed by Brother Felix John, Philadelphia, Pa.*

Three spheres of equal radii r rest on a table so that each sphere is tangent to the other two. Another sphere of radius r rests on the three spheres. Find the distance from the fourth sphere to the table.

Solution by Charles H. Butler, Kalamazoo, Mich.

The centers of the three spheres resting on the table determine a plane P parallel to the surface of the table and at a distance r above it. The centers of the four spheres are at the vertices of a regular tetrahedron whose edge (e) is $2r$. Now the altitude (h) of a regular tetrahedron of edge e is known to be $e\sqrt{6}/3$, or in this case $2r\sqrt{6}/3$, which is the distance from the center of the fourth sphere to the plane P. Therefore the distance from the lowest point on the fourth sphere to plane P is

$$\frac{2r\sqrt{6}}{3}-r.$$

But plane P itself is at a distance r above the table. Therefore the distance from the lowest point on the fourth sphere to the table is

$$\left(\frac{2r\sqrt{6}}{3}-r\right)+r=\frac{2r\sqrt{6}}{3}.$$

This is the distance required.

Solutions were also offered by Leon Bankoff, Los Angeles, Calif.; Donald R. Byrkit, West Chicago, Ill.; Ronald Klipsch, Indianapolis, Ind.; W. R. Talbot, Jefferson City, Mo.; C. W. Trigg, Los Angeles, Calif.; Lowell Van Tasell, San Diego, Calif.; Dale Woods, Kirksville, Mo.; and the proposer.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2707, 2708, 2709, 2710, 2711. *Lee H. Mitchell, University of Michigan.*

PROBLEMS FOR SOLUTION

2731. *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the system

$$\begin{gathered} a+b+c+d+e=3 \\ a^2+b^2+c^2+d^2+e^2=-7 \\ a^3+b^3+c^3+d^3+e^3=-3 \\ a^4+b^4+c^4+d^4+e^4=25 \\ a^5+b^5+c^5+d^5+e^5=-7. \end{gathered}$$

2732. *Proposed by John Nayler, Calgary, Alberta, Canada.*

The inscribed circle and the three escribed circles are drawn for a scalene triangle. How many finite circles can then be drawn tangential to three of these four circles?

2733. *Proposed by Cecil B. Read, Wichita, Kans.*

Prove that:

$$\sin \pi/14 \cdot \sin 3\pi/14 \cdot \sin 5\pi/14 = 1/8.$$

2734. *Proposed by Donald R. Byrkit, West Chicago, Ill.*

Prove that the probability that a fraction is in lowest terms is $6/\pi^2$.

2735. *Proposed by O. F. McCrary, Raleigh, N. C.*

Arrange the digits from 1 to 9 in a triangle in such a way that when added each side of the triangle will total 20. How would you find out how many possible combinations there are, that will total 20 on each side, when added?

2736. *Proposed by D. Moody Bailey, Princeton, W. Va.*

P is a point within triangle ABC and rays from A, B, and C through P meet the opposite sides a, b, and c in points D, E, and F, respectively.

$$AF/FB=a+b/b+c,\ BD/DC=a+b/a+c,\ CE/EA=b+c/a+b.$$

Show that P is the incenter of the medial triangle $A'B'C'$ of triangle ABC.

EDITOR'S NOTE: THE PROBLEM SECTION OF SCHOOL SCIENCE AND MATHEMATICS IS IN NEED OF SOME NEW AND INTERESTING PROBLEMS.

EDITOR'S NOTE: UNTIL JUNE 1960 THIS DEPARTMENT WILL OFFER TWO PROBLEMS ESPECIALLY FOR HIGH SCHOOL STUDENTS. ALL TEACHERS ARE ENCOURAGED TO HAVE THEIR STUDENTS SUBMIT PROBLEMS AND SOLUTIONS FOR THIS SPECIAL SECTION OF THE PROBLEM DEPARTMENT.

STUDENTS SENDING IN SOLUTIONS AND SUBMITTING PROBLEMS FOR SOLUTION SHOULD OBSERVE THE FOLLOWING INSTRUCTIONS:

1. EACH SOLUTION SHOULD BE IN TYPED FORM, DOUBLE SPACED.
2. DRAWINGS IN INDIA INK SHOULD BE ON A SEPARATE PAGE FROM THE SOLUTION.
3. PROBLEMS AND SOLUTIONS SHOULD BE IN THE SAME FORM THAT APPEARS IN THE *JOURNAL*.
4. EACH PROBLEM SHOULD BE ON A SEPARATE SHEET OF PAPER.
5. IN GENERAL WHEN SEVERAL SOLUTIONS ARE CORRECT, THE ONE SUBMITTED IN THE BEST FORM WILL BE USED.

STUDENT PROBLEMS FOR SOLUTION

S-**5.** *Proposed by Brother Norbert, Chicago, Ill.*

If the hypotenuse of two right triangles are equal, and the four sides are unequal in a given order, then the respective angles opposite the sides are unequal in the same order.

S-**6.** *Proposed by Lee H. Mitchell, Ann Arbor, Mich.*

a, b, c, and d form a harmonic progression and $(a+b)/(c+d)=1$. Find a/b and c/d.

SPECIAL NOTICE
TO
MEMBERS OF THE CENTRAL ASSOCIATION

Members of the Central Association of Science and Mathematics Teachers are invited to submit to the Nominating Committee names of members whom they would like to recommend for nomination for office in the election to be held in November, 1960. Officers to be elected at that time are President, Vice-president, and four members of the Board of Directors. On or before May 25, 1960, names should be sent to the chairman of the nominating Committee:

Mrs. Marie S. Wilcox,
Thomas Carr Howe High School,
Indianapolis 7, Indiana

Books and Teaching Aids Received

ROADS TO DISCOVERY, by Ralph E. Lapp. Cloth. 191 pages. 14×21 cm. 1960. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Price $3.75.

QUALIFICATIONS AND TEACHING LOADS OF MATHEMATICS AND SCIENCE TEACHERS, by Kenneth E. Brown and Ellsworth S. Obourn. Paper. Pages III–101. 26×19.5 cm. 1959. United States, Government Printing Office, Washington D. C. Price $.70.

SOLID GEOMETRY, by Avery Stone. Cloth. Pages v–245. 15×22.5 cm. 1960. Allyn and Bacon, Inc., Boston, Mass.

WILDLIFE IN DANGER, by Ivah Green. Cloth. 128 pages. 16×22 cm. 1960. Coward-McCann, Inc., 210 Madison Ave., New York, N. Y. Price $3.50.

ELEMENTARY ANALYSIS, by H. C. Trimble and F. W. Lott, Jr. Cloth. Pages V-621. 15×23 cm. 1960. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y. Price $6.95.

CHEMISTRY FOR OUR TIMES, by Elbert C. Weaver and Laurence S. Foster. Cloth. Pages iii–666. 23.5×15 cm. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. 1960. Price $5.72.

MINERAL EQUILIBRIA, by Robert M. Garrels. Cloth. Pages ix–254. 15×23 cm. 1960. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Price $6.00.

STRATIGRAPHIC PRINCIPLES AND PRACTICE, by J. Marvin Weller. Cloth. Pages v–725. 23×15 cm. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Price $10.00. 1960.

HIGH SCHOOL GEOMETRY, by Rachel P. Keniston and Jean Tully. Cloth. Pages iii–474. 16×23 cm. Ginn and Company, Statler Building, Boston 17, Massachusetts. Price $4.40. 1960.

HOW TO USE GRID-DIP ISCILLATORS, by Rufus P. Turner. Paper. Pages v–103. 14×21.5. John F. Rider Publisher, Inc., 116 West 14th Street, New York 11, New York. Price $2.50. 1960.

MATHEMATICS SECOND COURSE, by John A. Brown, Bona Lunn Gordey, Dorothy Sward and John R. Mayor. Cloth. 365 pages. 15×23 cm. 1960. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $3.64.

PLANT PHYSIOLOGY, by Bernard S. Meyer, Donald B. Anderson and Richard H. Bohning. Cloth. Pages iii–541. 15×22.5 cm. 1960. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, New Jersey. Price $7.50.

CHEMICAL MAGIC, by Leonard A. Ford. Cloth. 141 Pages. 13×21 cm. 1959. T. S. Denison & Co., 321 Fifth Avenue So., Minneapolis 15, Minn. Price $3.50.

OUR ENVIRONMENT, ITS RELATION TO US, by Paul E. Smith. Cloth. Pages xiii +464. 16×23.5 cm. 1960. Allyn and Bacon Co., 150 Tremont St., Boston, Mass.

OUR ENVIRONMENT, HOW WE USE AND CONTROL IT, by Gordon E. Van Hooft. Cloth. Pages xvi+688. 15.5×23.5 cm. 1960. Allyn and Bacon Co., 150 Tremont St., Boston, Mass.

OUR ENVIRONMENT, HOW WE ADAPT OURSELVES TO IT, by Paul E. Smith. Cloth. Pages xiii+625. 16×23.5 cm. 1960. Allyn and Bacon Co., 150 Tremont St., Boston, Mass.

BASIC GEOMETRY, by George David Birkhoff and Ralph Beatley. Cloth. 294 Pages. 13×20 cm. 1959. Chelsea Publishing Company, 50 E. Fordham Rd., New York 68, N. Y. Price $3.95.

ELEMENTS OF ALGEBRA, by Howard Levi. Cloth. Pages xi+161. 13×20 cm. 1960. Chelsea Publishing Company, 50 E. Fordham Rd., New York 68, N. Y. Price $3.25.

STRING FIGURES AND OTHER MONOGRAPHS, by W. W. R. Ball. Cloth. Pages vi+136. 13×20 cm. 1960. Chelsea Publishing Company, 50 E. Fordham Rd., New York 68, N. Y. Price $3.95.

CHEMISTRY, Laboratory, Teacher's Guide, Volume one, by Chemical Bond Approach Committee. Paper. Pages iv+42. 21.5×27.5 cm. 1959. The Reed Institute, Portland, Oregon.

CHEMISTRY, Laboratory, Volume one, by Chemical Bond Approach Committee. Paper. Pages iv+27. 21.5×27.5 cm. 1959. The Reed Institute, Portland, Oregon.

CHEMISTRY, Trial Edition, by Chemical Bond Approach Committee. Volume one. Paper. Pages viii+108. Volume two. Paper. Pages 109–246. Both 21×28 cm. 1959. The Reed Institute, Portland, Oregon.

ALGEBRA: ITS BIG IDEAS AND BASIC SKILLS, by Daymond J. Aiken, Kenneth B. Henderson and Robert E. Pingry. Cloth. Pages v–434. 15×22.5 cm. 1960. McGraw-Hill Book Company, Inc., New York, N. Y.

THE PRESIDENT'S REVIEW, by Warren Weaver. Paper. Pages iii–168. 14.5×21 cm. 1958. The Rockefeller Foundation, 49 West 49th Street, New York, N. Y.

INTRODUCTION TO HIGHER MATHEMATICS, by Constance Reid. Cloth. Pages v–184. 13×20 cm. 1959. Crowell Press, Inc., 432 Fourth Ave., New York, N. Y. Price $3.50.

HOW TO USE METERS, by John F. Rider and Sol D. Prensky. 210 Pages. Paper. 14×21 cm. 1959. John F. Rider Publisher, Inc., 116 West 14th Street, New York 11, New York. Price $3.50.

THE WORLD OF THE MICROSCOPE, by L. J. Ludovici. Cloth. 128 pages. 15×20 cm. 1959. G. P. Putnam's Sons, 210 Madison Ave., New York, New York. Price $2.95.

MOON BASE, by Dr. T. C. Helvey. Paper. Pages iii–72. 14×21.5 cm. 1960. John F. Rider Publisher, Inc., New York, New York. Price $1.95.

MATHEMATICS FIRST COURSE, by John A. Brown, Bona Lunn Gordey, and Sward, John R. Mayor. 323 pages. 15×23 cm. 1960. Prentice-Hall Inc., Englewood Cliffs, N. J.

RADAR SIGNAL SENT TO SUN AND BACK

A radar signal has been sent with the speed of light from earth to the sun and back, marking man's first direct contact with the sun.

The signal took 17 minutes to make the round trip to the star that is the center of the solar system.

The sun was very difficult to reach by radar because of the thunderous radio noise arising from its turbulent surface, as well as its great distance, some 93,000,000 miles.

The solar radar echo did not come from the sun's visible surface, but from its outer corona, the pearly white upper atmosphere of the sun usually visible only at time of an eclipse.

Book Reviews

COLLIER'S ENCYCLOPAEDIA, Edited by William T. Couch. Cloth. 20 volumes with Bibliography and Index. Each volume 21×27 cm. 1959. P. F. Collier and Son Corporation. New York, N. Y.

This reviewer has had opportunities from time to time to evaluate a number of encyclopaedic publications. One learns quickly that such documents are not read page by page like a textbook. There are two basic reasons:

1. These publications are not designed to be read from cover to cover as is true with textbooks. The "proof of the pudding" is determined by constant use of the publication as a reference work.
2. The task of reading 20 volumes (including the Index) would be formidable indeed since all of them have more than 700 pages.

Thus, for a period of six months the reviewer put *Collier's Encyclopaedia* into service, chiefly as a reference for science and mathematics. At least once a day, and sometimes as often as twenty times a day, the volumes were consulted for information in the areas mentioned. The encyclopaedia was never found to be wanting. In all cases, it delivered the desired material and delivered superbly.

The encyclopaedia consists of twenty (20) volumes in which the subjects are arranged alphabetically. The last volume is the Bibliography and Index. The volumes are bound in attractive black buckram and lettered in red. They give every evidence of being sturdy, durable and resistant to hard wear.

The textual material is printed in small, but extremely readable type. The headings and subheadings are in black boldface and stand out sharply and clearly. The glossy paper is not so shiny as to bother the eyes.

On several occasions the reviewer compared the presentation of topics in this publication with the presentation of topics in similar encyclopaedias. In every case, *Collier's*, in the opinion of the reviewer, did as well or better.

In use the reviewer never failed to locate the material he wanted.

The encyclopaedia is not a publication for the elementary or junior high school levels. A few of the better students would find it useful, but in general, the presentation is too sophisticated. However, it will serve admirably for the high-school levels and higher.

Without question, the reviewer prefers this encyclopaedia to any one of its type that he has seen. It is difficult to believe that any school or other organization could go wrong by owning these volumes.

G.G.M

A BRIEF TEXT IN ASTRONOMY, by William T. Skilling, *San Diego State College*, and Robert S. Richardson, *Mount Wilson and Palomar Observatories*. Cloth. Pages x+353. 16×23.5 cm. 1954, 1959. Henry Holt and Company, Inc., 383 Madison Avenue, New York 17, N. Y. Price $6.00.

A Brief Text In Astronomy is a revision of an earlier textbook in which several important and interesting changes have been made. In addition to the topics usually discussed in a textbook of this type, sections on radio astronomy, artificial satellites, and space travel are presented. New photographs and diagrams have been added and some figures have been re-drawn. Star maps of the twelve months are included in the book.

One criticism of this book might be that the new chapters on Artificial Satellitec and Space Travel could have been extended to a more complete discussion than is found in the sixteen pages of the new material. The treatment of these new topics would have been improved by the use of some photographs rather than diagrams alone. However, the inclusion of the new topics is interesting and definitely improves the textbook.

This textbook is written primarily for use in a freshman or sophomore course in a department of Astronomy. However, it could also be used in astronomy courses frequently offered in other departments.

This book is worthy of consideration by anyone interested in adopting an up-to-date textbook in Astronomy.

J. Bryce Lockwood
Highland Park Junior College

Everyday Problems in Science, by Wilbur L. Beauchamp, John C. Mayfield, Joe Young West. Cloth. 528 pages. 20×23 cm. 1959. Scott, Foresman and Co., Chicago, Ill.

This textbook is one of a long line of references from Scott Foresman and Company designed for courses in general science for the ninth-grade. It is, however, one of the multi-purpose textbooks designed for use at various levels within the program of science in the junior-high-school. It is not an integral part of a junior-high-school series.

An examination of the table of contents indicates that all the traditional areas of general science are included. The textual material is printed in two columns of type and formal that should pose no great problem with respect to reading level. The illustrations are varied in style and in position from page to page. Thus the "illustrative monotony" that is found in many books is not present. There are only a few "openings" in which illustrations do not appear.

In revising this book, it is obvious that an effort was made to make the book attractive by using signatures of four color. These improvements have accomplished a great deal in improving the book over the earlier editions.

The date of publication of course negates the possibility of including material on satellite launchings, lunar probes, and the findings of the IGY. Further, the second color is not used throughout the book as is true in books that have been published more recently.

Nevertheless, the book is well written, covers the material well and has an attractive appearance. With some supplementation it will serve more than adequately at the levels for which it is designed.

G.G.M.

BERYLLIUM "WONDER METAL" NEARLY READY FOR USE

The "wonder metal" beryllium is expected to take its place in industry as a workhorse metal in about two years.

Beryllium is a strong, lightweight, toxic metal that could cut the weight of a transport airplane about 50% if used instead of aluminum. This relatively scarce metal had generally been ignored until the Space Age demanded new strength, weight and heat-absorbing properties in structural metals.

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Although the metal now costs about $100 a pound in powder form, producers predict that any real application of beryllium in the aircraft industry will "result in drastically reduced prices."

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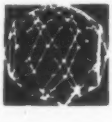

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